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*A Review of Flight-Initiation Distances and their Application to Managing Disturbance to Australian Birds*

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## **A review of flight initiation distances and their application to managing disturbance to Australian birds**

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26   **Abstract**

27   Disturbance, the response of birds to a stimulus such as the presence of a person, is  
28   considered a conservation threat for some Australian birds. The distance at which a  
29   bird flees from perceived danger is defined as the Flight Initiation Distance (FID), and  
30   could be used to designate separation distances between birds and stimuli which  
31   might cause disturbance. We review the known FIDs for Australian birds, and report  
32   FIDs for 352 species. Most FIDs are from south eastern Australia, and almost all refer  
33   to a single walker as the stimulus. A number of prominent factors correlated with FID  
34   are discussed (e.g. body mass and the distance at which an approach begins). FIDs  
35   have not been used extensively in the management of disturbance, for a variety of  
36   reasons including lack and inaccessibility of available data. We call for standardised  
37   data collection and greater application of available data to the management of  
38   disturbance.

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## Introduction

The response of birds to the presence of a stimulus such as a potential predator or a human is referred to as ‘disturbance’ (Van Der Zande and Verstrael 1985; Fox and Madsen 1997). A diverse range of *stimuli* can disturb birds. Although natural stimuli, such as predators, cause disturbance (e.g. Ward *et al.* 1994; Burton *et al.* 1996), most studies focus on anthropogenic sources of disturbance. These include humans themselves, their companion animals, and motorised transport such as aircraft, vehicles and boats (e.g. Kushlan 1979; Andersen *et al.* 1989; Buick and Paton 1989; Kirby *et al.* 1993; Burger 1998; Delaney *et al.* 1999).

The *response* of birds to disturbance takes many forms, but most reported responses are behavioural and can be considered vigilance or flight responses (Hediger 1934; Ydenberg and Dill 1986; Hockin *et al.* 1992), where ‘vigilance’ involves birds stopping their current activity to monitor the approaching human (e.g. Fernández-Juricic *et al.* 2001) and ‘flight’ involves fleeing on foot, swimming, diving, or on the wing (e.g. Cooke 1980). An increasing number of studies have demonstrated physiological responses to stimuli, such as changes in heart rates, body temperature, and plasma corticosterone levels, which can occur in the absence of any obvious behavioural responses (e.g. Gabrielsen *et al.* 1977; Kanwisher *et al.* 1978; Culik *et al.* 1990; Wilson *et al.* 1991; Culik *et al.* 1995; Nimon *et al.* 1995, 1996; Regel and Pütz 1997; Weimerskirch *et al.* 2002; Walker *et al.* 2006). Responses to disturbance can vary greatly between species. For example, some shorebirds do not leave their nest until humans are nearby, while others leave their nests when humans are several hundred metres distant (e.g. Page *et al.* 1983; Watson 1988; Yalden and Yalden 1989).

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66           These behavioural and physiological responses are presumed to be costly, and  
67 non-benign consequences of human disturbance have been observed among many  
68 species. Disturbance induced by humans can result in ecologically significant shifts in  
69 behaviour, such as changes in habitat use (e.g. Burger 1981), reduced foraging,  
70 diminished parental care (e.g. Weston and Elgar 2005), compromised parental defence  
71 resulting in reproductive failure (e.g. Vos *et al.* 1985), among other changes.  
72 Behavioural changes, such as those associated with disturbance, are often assumed to  
73 be brief, yet may ultimately have long-lasting impacts on populations (e.g. Flemming  
74 *et al.* 1988). At the population level, high species sensitivity to disturbance (i.e. long  
75 ‘Flight Initiation Distances’ [FIDs]) is associated with population declines among  
76 European birds (Møller 2008) and, in the Cordoba Mountains of Argentina, human  
77 presence negatively influenced avian communities, guilds and populations (Heil *et al.*  
78 2007).

79

80           Increasing exposure of birds to disturbance, the possibility of significant  
81 negative impacts on the conservation of at least some species, and the legislative  
82 requirements to conserve birds and protect bird welfare, have largely prompted a  
83 dramatic increase in the number of publications on disturbance to birds over the last  
84 35 years (Hockin *et al.* 1992; Hill *et al.* 1997; Price 2008). This considerable body of  
85 work has emphasised the high variability of the forms and consequences of  
86 disturbance to birds. Many studies of disturbance examine factors that mediate  
87 responses to disturbance. For example, physical factors such as habitat, internal  
88 factors such as learning, and attributes of the stimulus such as number, height and  
89 width, and speed of approach can all influence avian responses (e.g. Stalmaster and

Newman 1978; Burger 1986; Keller 1989; Rodgers and Smith 1995; Jorden 2007). An almost universal theme in the literature is that most forms of disturbance to birds are already common and are likely to occur with greater frequency in the future. Increases in disturbance to birds have been predicted for Europe, North America and Australia (e.g. Boden and Ovington 1973; Goss-Custard and Verboven 1993; Kirby *et al.* 1993; Flather and Cordell 1995; Gill *et al.* 1996; Hill *et al.* 1997).

Here, we briefly review Flight Initiation Distances (FID) among Australian birds and some of the factors which may mediate FID. Specifically, this review critically describes FID and associated concepts, describes some prominent factors which mediate FID, and considers why FID estimates have not enjoyed greater application in the management of avian disturbance. We redress one barrier to the use of FID data in management by providing available FID data for Australian birds. We are unaware of any published reviews dedicated to this topic to date (but see Lane 2003).

### **Bridging the theoretical-applied divide: Flight Initiation Distances**

One of the most consistent findings of disturbance research is that the response of birds is inversely related to the distance between the bird and the stimulus. The distance at which a behavioural escape response occurs is known as Flight Initiation Distance (FID) (Stankowich and Blumstein 2005), a concept apparently first described by Hediger (1934). FID is also known as ‘Flush’ (Stankowich and Blumstein 2005), ‘Displacement’ (Dandenong Valley Authority 1979) or ‘Flight’ Distance (Hediger 1934). The distance at which a vigilance response is initiated is the Alarm Initiation Distance (AD), also known as ‘Agitation’ Distance (Dandenong

Valley Authority 1979) (Fig. 1). The concept of FID is broadly applicable to wild living birds, though for aggressive, highly habituated or domesticated birds, the response often involves an approach to humans, and FID may not adequately reflect the distance at which normal activities are disrupted. Alarm responses vary between species, but many involve raising the head and communicating with nearby conspecifics via alarm calls or other signals such as tail flicking among the Rallidae (Woodland *et al.* 1980). Non-cryptic promulgation of alarm may also signal to threatening stimuli that they have been detected (Woodland *et al.* 1980). If AD is evident, it is always greater than or equal to FID (Blumstein *et al.* 2005; Cárdenas *et al.* 2005).

Two other important distances that are often overlooked are: 1) the possible existence of Detection Distance (DD), the distance at which a bird can first detect a stimulus (generally assumed to be visually, though auditory cues could potentially be used to detect loud stimuli such as aircraft, or the sounds of approaching predators in closed habitats) without reacting in other ways, and 2) the Physiological Initiation Distance (PID), the distance at which physiological response (e.g. increased heart rate or corticosteroid secretion) is initiated (Fig. 1). Birds can detect stimuli while not being overtly vigilant and thus DD is greater than or equal to AD (Lima and Bednekoff 1999). The few studies of PID suggest that it is longer than either AD or FID (Nimon *et al.* 1996), at least in ‘non-startle’ responses (see below).

Starting distance (the distance at which an investigator approach begins; SD), is usually positively related to FID (Blumstein 2003, 2006, 2010), however where FID and DD are very similar or the same, the response of the birds can be considered a

‘startle’ response, defined as an instantaneous flight response upon detection of the stimulus. Startles occur at distances below which FID equals SD. Maximum startle distance can be estimated from the regression of FID and SD as the point where FID equals SD for a given species. DD is currently not measurable, so startles occur when the distance at which an approach begins (Starting Distance; SD) equals or is very similar to FID. Essentially, this represents the presentation of a stimulus to a bird rather than an approach. For species with long FIDs, caution must be exercised in relation to achieving sufficient starting distances during approaches; insufficient starting distance may result in only the least sensitive individuals contributing to the measure of FID.

#### **Prominent factors correlated with FID**

Life history characteristics influence many aspects of the behaviour of birds, and can be reasonably expected to influence key aspects of decisions in relation to escape behaviour such as flight (Møller and Garamszegi 2012). For example, males and females, old and young individuals, and low and high quality individuals could differ consistently in direction and magnitude of FID. However, studies which examine these attributes in relation to FID are few (but see Thiel *et al.* 2007). FID itself can be considered a life history trait, whereby FID represents the risk an individual is willing to take, which is expected to be influenced by residual reproductive value (the remaining reproductive value for an individual of a particular age, given it’s particular condition, quality etc.). Thus, associations between FID and other life history traits represent correlations and do not necessarily imply causation.

Body mass, a life history trait, explains most of the variation in FID among species (Blumstein 2006). To highlight the importance body mass, residuals from a



regression of FID on body mass (both logged [10]) for species with at least ten FIDs and with adequate mass data are presented in Appendix 1 (no phylogenetic corrections;  $F_{1,138} = 131.471$ ,  $P < 0.001$ ,  $R^2 = 0.488$ , slope = 0.296; Fig. 2). Higher positive residual values indicate species most sensitive to human approaches while negative values of higher magnitude indicate species least sensitive to human approaches. The Hooded Plover *Thinornis rubricollis* has the highest residual value, and is a species considered to be threatened by human disturbance (Dowling and Weston 1999). The least sensitive species analysed was the Australian Brush Turkey *Alectura lathami* which sometimes inhabits yards and other human-dominated environments (Marchant and Higgins 1993).

There are several possible reasons for the general finding that FIDs and body sizes are positively correlated between species. First, if larger-bodied species are more at risk from predators due to their higher detectability, they may diminish depredation risk by initiating the flight response earlier (Holmes *et al.* 1993). Second, if larger-bodied species are less agile or aerodynamic than smaller species, they may require more time or space to escape (Fernández-Juricic *et al.* 2002). Third, smaller-bodied species may require more foraging time to fulfill their relatively higher energy requirements and thus may react later to disturbance to maximise foraging time (Bennett and Harvey 1987; Blumstein 2006). Other possibilities include that humans may have discriminately hunted or hunt larger species, or that larger species may exhibit higher longevities (i.e. have, on average, higher residual reproductive values) and so minimise risk associated with perceived threats. A number of parameters correlated with body mass may also be correlated with FID, including sensory organ and brain size and the height of the eye above the substrate; some of these parameters

are positively correlated with FID once body mass has been accounted for (Møller and Erritzøe 2010) and others remain to be investigated.

Larger group sizes are, at least sometimes, associated with longer FIDs; possibly because the flock's response is dependent on the reaction of the most alert, sensitive or risk-averse constituent of the flock (Cooke 1980; Hilton *et al.* 1999; Fernández-Juricic *et al.* 2002), and because at least some birds may initiate a response when nearby birds respond (Hingee and Magrath 2009). However, the reduction in individual vigilance associated with an increase in group size is a frequently reported relationship, and is generally thought to result from a decrease in predation risk to flock members, or an increase in competition among foraging flock members (Roberts 1996; Beauchamp 2001; Randler 2005). Flocking species may be more susceptible to disturbance from humans than species that do not flock, both at the individual and possibly the population levels. More studies are required to determine if a threshold in group size exists above which FIDs do not increase but theory predicts that because the benefits of increasing group size attenuate quickly, studies of animals in relatively small group sizes will be important to describing this function.

Learning is an oft cited influence on escape behaviour such as FID, but no studies on birds known to us unambiguously describe changes in FID with experience i.e. learning (see below). Learning, if it occurs, could potentially influence FIDs in two directions: 1) facilitation ('sensitisation'), where FIDs increase with increasing exposure to humans; and, 2) habituation where FIDs decrease with increasing exposure to humans. The former is generally suggested to be associated with dangerous, irregular, rapid and unpredictable stimuli such as hunters (Thiel *et al.*

2007), and dogs which are most commonly unleashed in many bird habitats (see Williams *et al.* 2009). In contrast, habituation is suggested to result from frequent benign, slow and predictable stimuli like walkers (Weston and Elgar 2007). Both types of learning might potentially occur within a species. Such an explanation might explain examples of behaviour such as the Pacific Black Duck *Anas superciliosa*, which in urban parks, where the species is fed, actually approaches humans closely, while in areas where it is hunted, flushes at many hundreds of metres (Unpubl. Data, but see below). The capacity of learning, if any occurs, on the part of birds to change FIDs is little studied and poorly known (but see Gould *et al.* 2004), but within species variation in FID might at least partly reflect learning .

Learning has been inferred from the prevalence of humans in particular habitats and the responses of birds in those habitats (i.e. a space – experience substitution). For example, Black Swan *Cygnus atratus* FIDs toward walkers have been measured by many observers at different sites and vary from 149 m in the relatively undisturbed Coorong, SA (Paton *et al.* 2000), to only 3.6 m at the extremely busy Albert Park Lake, Melbourne (Monie 2011). Such variation has been used to infer habituation. However, evidence of this type does not necessarily demonstrate learning, and a number of problems exist when using space-experience substitution studies to infer learning. Firstly, dispersal and site fidelity of the species measured will influence the experience of birds at a site and few such studies document the underlying regimes in the occurrence of stimuli (e.g. density or frequency of humans) which are often assumed (but see Glover *et al.* 2011). Additionally, site comparisons are often confounded with habitat, and many comparisons of these types involve urban and rural or ‘natural’ comparisons (e.g. Cooke 1980). Space – experience

substitutions may also be confounded by the possibility of selection for, or biased recruitment of, less responsive birds in more disturbed habitats. Observed patterns may thus reflect selective pressure or differential recruitment, rather than learning *per se*. We are unaware of any study that examines the actual experience of free-living individual birds and their response to humans, and we are similarly unaware of any study which discriminates between the potential mechanisms underpinning reported differences in bird responses between birds inhabiting sites experiencing different disturbance regimes. The capacity, if any, for learning on the part of the birds and subsequent adjustment of FIDs thus remains virtually unstudied, poorly known, and is ripe for future study.

Starting distance (i.e. the distance at which an approach begins; SD) is positively related to FID for most species (Blumstein 2003, 2006). It has been hypothesised that this intriguing finding results from a judgement regarding the value of a ‘patch’ under increasing risk (i.e. an approaching human; Blumstein 2003, 2006). However, an alternative explanation may be that birds monitor approaches and tolerate them for a certain time (and thus maintain a temporal margin of safety; Dill 1990) perhaps a measure of the ‘persistence’ of the approach. Or, individuals may tolerate approaches to a certain proportion of AD such as is seen in galahs (*Cacatua roseicapilla*; Cárdenas *et al.* 2005) and perhaps other species (Gulbransen *et al.* 2006). Alternatively, animals may tolerate approach until a threshold in the perception of the stimulus (e.g. increasing size) is reached (Jorden 2007). Many species of birds do not have a large binocular overlap region frontally and thus may not be able to estimate distance efficiently. Obviously, time and distance are highly correlated during a human approach at a constant speed, which could explain the significant correlation

between SD and FID, although distance *per se* may not be used by birds to decide when to respond to stimuli (but see Cárdenas *et al.* 2005). Further research into teasing apart these alternative mechanisms remains to be conducted.

The factors listed above are those that feature prominently in the literature. Blumstein (2006) suggested after body size, diet and sociality (i.e. whether a species is a co-operative breeder) also explained significant variation in avian FID. However, many other potential correlations with FID remain to be investigated thoroughly. For example, birds with more pointed wings have longer FIDs and fly further when disturbed compared with birds with more rounded wings (Fernández-Juricic *et al.* 2006) and ‘personality’ may explain some of the variation of FIDs seen within species. More ‘exploratory’ individual Collared Flycatchers *Ficedula albicollis* tend to have smaller FIDs than less exploratory individuals (Garamszegi *et al.* 2009). Other potential influences on FID include age, sex, site attributes including distance from cover and the presence of barriers to human movement such as fences or canals, weather, clothing colour and others mentioned throughout this review (see, for example, Fruziski 1977; Gutzwiller and Marcum 1993; Gould *et al.* 2004; Thiel *et al.* 2007; Fong *et al.* 2009).

#### **FID as a management tool: strengths and shortcomings**

One of the attractions of documenting FIDs is that they provide a scientific basis for the designation of buffers or separation distances between important habitat and incompatible surrounding land uses, often recreation (Blumstein and Fernández-Juricic 2010). Other approaches to mitigate the impacts of disturbance include altering the behaviour of the stimulus, for example by implementing ‘codes of conduct’,

hiding the stimulus (e.g. hides) or by promoting habituation, such as through the use of fences (Ikuta and Blumstein 2003), which make stimuli more predictable and physically separate them from birds so rendering them less threatening (Gates and Gysel 1978). Despite the potential of buffers to restrict any negative effects of disturbance (Davies and Lane 1995), and because of a range of competing factors, FIDs have rarely been used in this way in Australia (Weston *et al.* 2009). Their use has been limited by a number of ecological, scientific and social factors which are discussed below.

Relatively few studies in Australia have provided measures of FIDs although data on some species with global distributions are available from overseas (e.g. Møller and Erritzøe 2010). Many older studies of FID relied on subjective measurement of distance and so used distance categories (e.g. Woodland *et al.* 1980). However, the availability of cost-effective eye-safe laser range finders, which permit accurate measurements of distances at scales relevant to bird FIDs, means collecting data on FIDs is now comparatively cheap and accurate. Despite this, published data on FIDs of Australian birds are only available for 29.3% of the 866 species of birds that occur in Australia (Table 1). Thus, comparatively few FIDs are readily available to managers. Of the 352 FIDs on Australian birds we located, only 48.6% were published in peer-reviewed literature. The remaining FIDs were published in reports with limited circulation, or reports that are difficult to access (e.g. honours theses or other ‘grey literature’; a finding that is paralleled on other continents). The lack of suitable data on which to make management decisions could be addressed by collecting more FID on more species in more locations and encouraging its publication in a form usable for managers. In the interim, estimates from the

widespread, positive relationship between body mass and FID, and the species specific residuals from the relationship (Blumstein 2006), may be used as a first approximation or to identify particularly sensitive species and these estimates can be tested and refined with future study. Clearly, the later approach relies on information regarding the species present at a site, and assumes the site is not already avoided by particularly sensitive species.

There has been a taxonomic bias in available FIDs for Australian birds. 34.0% (of 377 species) and 45.8% (of 489 species) of passerines and non-passerines respectively have published FIDs. In particular, most research has targeted waterbirds, in particular shorebirds (75.9% of 224 species; Table 1). As a result, there are many groups of birds for which few or no FIDs are available. There has also been a regional bias in studies of the FIDs of Australian birds, with most reported from temperate areas (usually coastal), in eastern Australia (where most of the human population resides; Fig. 3), and a habitat bias, with most FIDs available from wetlands, few from grasslands, and few studies which specify the microhabitat of focal birds such as substrate (e.g. for wetland birds, margin or water) (but see Blumstein 2006).

The great majority of reported FIDs involve non-breeding birds, although disturbance can reduce reproductive success in some species (Davidson and Rothwell 1993) and disturbance has been associated with decline among breeding populations of others (Møller 2008). Breeding birds potentially respond very differently to disturbance compared with non-breeding birds (Glover *et al.* 2011), and few studies report FIDs for dependent or flightless young.

FIDs are reported in non-standard ways in the scientific literature, and are presented as averages (e.g. Blumstein 2006) sometimes without measures of variation, as 95<sup>th</sup> percentiles (e.g. Taylor 2006), or as maxima (Glover 2009). Moreover, a central repository for FID data is not available to managers. Given that virtually nothing is known about the thresholds of response frequencies or intensities which can be tolerated by birds, the precautionary principle suggests that an upper limit is required, this could be 95<sup>th</sup> percentiles (which still assumes thresholds in tolerance), or maxima (if sampling is sufficient), which would be most appropriate for the designation of buffers for conservation purposes. In at least some cases the FIDs evoked by tangential approaches exceed those evoked by direct approaches (e.g. Heil *et al.* 2007; but see Burger *et al.* 2010) suggesting that such effects should be investigated before designating buffers, leading some authors to propose various inflation factors to FIDs (Fernández-Juricic *et al.* 2005; Blumstein and Fernández-Juricic 2010). We believe that it would seem prudent to present full summary statistics and methodological details of all FIDs in publications, to enable managers access and ready interpretation of the data (thus, see Table 2). Additionally, studies of experimentally implemented buffers, derived from FIDs, could inform how FIDs can be used to create effective buffers, and could account for a variety of stimulus types and behaviour, and if studies occur long enough, account for learning on the part of the birds. Studies which examine different methods of calculating buffers in relation to actual FIDs (Fernández-Juricic *et al.* 2005; Glover *et al.* 2011) are both needed and useful.

FIDs from mixed species flocks are not available either because studies have generally approached only single species flocks (e.g. Paton *et al.* 2000) or because



they assume that no species interactions occur and use a focal bird approach (Blumstein *et al.* 2003). However, many species usually or often occur in mixed flocks (e.g. shorebirds, small passerines) and mixed flocks of shorebirds are known to ‘share’ vigilance with other species in flocks (Metcalf 1983). It may be that in mixed flocks the FID is that of the most sensitive individual irrespective of species, especially for closely or highly coordinated flocking species i.e., the ‘sentinel’ hypothesis (Metcalf 1983; Paton *et al.* 2000). Alternatively, it is possible that species respond only to the flight of conspecifics. These possibilities can be envisaged as the extremes of a spectrum. Interspecies interactive FIDs remain unstudied and their study may generate novel and practical insights into managing human disturbance at multi-species sites.

Another limitation of the FID data currently available is the emphasis on a single walker as the stimulus (92.3% of 352 FIDs). FIDs in response to other stimuli including dog walkers, joggers, powerboats, and canoes have only been reported for 11 species (some authors discuss the influence of different stimuli without directly reporting the FIDs e.g. Glover *et al.* 2011). Although walkers are a useful standard for comparative studies, FID can vary depending on the stimulus involved. For example, shorebirds have larger FIDs towards dog walkers than walkers without dogs (Paton *et al.* 2000; Glover 2009) and cars do not elicit as strong a response as walkers or cyclists among ducks (Pease *et al.* 2005). Larger groups of people may evoke longer FIDs (Geist *et al.* 2005). Aspects of the behaviour of stimuli also influence responses: for example, tangential approaches evoke different responses, sometimes longer FIDs, in comparison with direct ones (Blumstein and Fernández-Juricic 2010; Burger *et al.* 2010) and the behaviour of a human can dramatically influence the duration of a

response (Weston *et al.* 2011). Due to the strong effect of stimulus type, proper management decisions can only be made if FIDs for the prevailing human activities are available for the appropriate species. The use of FIDs for single walkers would underestimate the required buffer needed to protect birds from dog walkers. More studies of the influence of stimulus type on FID may enable some extrapolation of FIDs across stimulus types, which could be cautiously used by managers until better information becomes available. Indeed, currently it is not known whether birds respond specifically to each stimulus or generalise responses into ‘classes’. Different classes of FID are presumably correlated between individuals or species; understanding such patterns might provide general principles regarding what stimuli are likely to cause greatest disturbance. Ultimately, FID-based buffer zones should be viewed as hypotheses ripe for testing and studied in an adaptive management framework (Blumstein and Fernández-Juricic 2010).

Different authors have used various protocols to measure FIDs. The standard protocol, which has received the broadest patronage and thus seems logical to promote to future investigators, involves a slow continuous approach toward the target bird and the recording of AD and FID as the bird behaviour changes (Blumstein 2003). This would also seem to best mimic the behaviour of most recreationists (except possibly birdwatchers or photographers). Other researchers have opted for stepwise advances toward birds with behavioural observations in between each step to monitor vigilance within flocks (Paton *et al.* 2000). For birds in elevated positions, horizontal and vertical components of FID should be recorded and documented (Møller 2010). SD should be maximised or standardised (see Møller and Garamszegi 2012). Standardisation of the FID measuring protocol would enhance compatibility of

different datasets and we advocate that the simple method described by Blumstein (2003) should be adopted whenever possible.

Finally, FIDs may be impractical for planners, policy makers and other stakeholders such as the public, researchers and birdwatchers (see Glover *et al.* 2011). Some species exhibit FIDs of more than 100 m; the maximum FID recorded for any Australian species to date is 196 m for the Eastern Curlew *Numenius madagascariensis* (Glover *et al.* 2011); longer FIDs are likely to occur. Although many Australians accept the need for buffers against human disturbance (Glover *et al.* 2011), large buffers which exclude humans threaten coexistence, including with birdwatchers who at least occasionally cause disturbance (Clarke 1965; Sekercioglu 2002). Additionally, close personal encounters with wildlife such as birds, can be a powerful tool for public education and the recruitment of bird researchers, conservationists and advocates; strict buffers would exclude such experiences. However, FIDs can provide information on managing disturbance in ways other than exclusion zones. For example, constraining the extent of human presence (through formed paths or barriers such as fences or canals), and the promotion of habituation (by encouraging predictable and unthreatening behaviour of the stimuli), remain tantalising management responses to disturbance.

If response to humans is considered a major issue for bird conservation, then the lack of published FID data, and its limited use in management, seems at odds with the concept of scientific management. The divide between science and its application is hardly new, but it is frustrating and challenging to managers and scientists alike (Australian Biosecurity CRC 2009). The publication of raw FID data often does not

fulfil the more theoretical expectations of scientific journals, or aspirations of potential authors. Nevertheless, such data are required if the management of disturbance to birds is to improve. We encourage the development of a common data standard and sharing of these data to enhance the conservation of Australian birds.

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## References

- Australian Biosecurity CRC (2009). Knowledge into Practice and Policy. The Science-Policy Interface. (Australian Biosecurity CRC, Brisbane.)
- Adams, J. L., Camelio, K. W., Orique, M. J., and Blumstein, D. T. (2006). Does information of predators influence general wariness? *Behavioral Ecology and Sociobiology* **60**, 742-747.
- Andersen, D. E., Rongstad, O. J., and Mytton, W. R. (1989). Response of nesting Red-tailed Hawks to helicopter overflights. *Condor* **91**, 296-299.
- Australian Biosecurity CRC (2009). 'Knowledge into Practice and Policy. The Science-policy Interface.' (Final report by Australian Biosecurity CRC: Brisbane, Australia.)
- Beauchamp, G. (2001). Should vigilance always decrease with group size? *Behavioral Ecology and Sociobiology* **51**, 47-52.
- Bennett, P. M., and Harvey, P. M. (1987). Active and resting metabolism in birds: allometry, phylogeny and ecology. *Journal of Zoology* **213**, 327-363.

- 472 Blakney, A. H. (2004). Behavioural Responses and Habituation of the Hooded Plover,  
473 *Thinornis rubricollis* (Gmelin 1789), to Disturbance Stimuli. Honours Thesis,  
474 University of Tasmania, Hobart, Australia.
- 475 Blumstein, D. T. (2003). Flight initiation distance in birds is dependant on intruder  
476 starting distance. *Journal of Wildlife Management* **67**, 852-857.
- 477 Blumstein, D. T. (2006). Developing an evolutionary ecology of fear: how life history  
478 and natural history traits affect disturbance tolerance in birds. *Animal*  
479 *Behaviour* **71**, 389-399.
- 480 Blumstein, D. T. (2010). Flush early and avoid the rush: a general rule of anti-  
481 predator behavior? *Behavioural Ecology* **21**, 440-442.
- 482 Blumstein, D. T., Anthony, L. L., Harcourt, R., and Ross, G. (2003). Testing a key  
483 assumption of wildlife buffer zones: is flight initiation distance a species-  
484 specific trait? *Biological Conservation* **110**, 97-100.
- 485 Blumstein, D. T., and Fernández-Juricic, E. (2010). 'A Primer of Conservation  
486 Behavior.' (Sinauer Associates, Inc.: Sunderland, USA.)
- 487 Blumstein, D. T., Fernández-Juricic, E., Zollner, P. A., and Garity, S. C. (2005).  
488 Interspecific variation in avian responses to human disturbance. *Journal of*  
489 *Applied Ecology* **42**, 943-953.
- 490 Boden, R. W., and Ovington, J. D. (1973). Recreation use-patterns and their  
491 implications for management of conservation areas. *Biological Conservation*  
492 **5**, 265-270.
- 493 Boyer, J. S., Hass, L. L., Lurie, M. H., and Blumstein, D. T. (2006). Effect of  
494 visibility on time allocation and escape decisions in Crimson Rosellas.  
495 *Australian Journal of Zoology* **54**, 363-367.
- 496 Buick, A. M., and Paton, D. C. (1989). Impact of off-road vehicles on the nesting  
497 success of Hooded Plovers *Charadrius rubricollis* in the Coorong region of  
498 South Australia. *Emu* **89**, 159-172.
- 499 Burger, J. (1981). The effect of human activity on birds at a coastal bay. *Biological*  
500 *Conservation* **21**, 231-241.
- 501 Burger, J. (1986). The effects of human activity on shorebirds in two coastal bays in  
502 northeastern United States. *Environmental Conservation* **13**, 123-130.
- 503 Burger, J. (1998). Effects of motorboats and personalised watercraft on flight  
504 behaviour over a colony of Common Terns. *Condor* **100**, 528-534.
- 505 Burger, J., Gochfeld, M., Jenkins, C. D., and Lesser, F. (2010). Effect of approaching  
506 boats on nesting Black Skimmers: using response distances to establish  
507 protective buffer zones. *Journal of Wildlife Management* **74**, 102-108.
- 508 Burton, N. H. K., Evans, P. R., and Robinson, M. A. (1996). Effects on shorebird  
509 numbers of disturbance, the loss of a roost site and its replacement by an  
510 artificial island at Hartlepool, Cleveland. *Biological Conservation* **77**, 193-  
511 201.
- 512 Cárdenas, Y. L., Shen, B., Zung, L., and Blumstein, D. T. (2005). Evaluating temporal  
513 and spatial margins of safety in Galahs. *Animal Behaviour* **70**, 1395-1399.
- 514 Clarke, G. (1965). Disturbance of breeding and resting birds by bird-watchers. *South*  
515 *Australian Ornithologist* **24**, 41.
- 516 Cooke, A. S. (1980). Observations on how close certain passerine species will tolerate  
517 an approaching human in rural and suburban areas. *Biological Conservation*  
518 **18**, 85-88.
- 519 Culik, B., Adelung, D., and Woakes, A. J. (1990). The effect of disturbance on the  
520 heart rate and behaviour of Adélie Penguins (*Pygoscelis adeliae*) during the

521 breeding season. In 'Antarctic Ecosystems: Ecological Change and  
 522 Conservation'. (eds. K. R. Kerry, G. Hempel) pp. 177-182. (Springer-Verlag:  
 523 Berlin, Germany.)  
 524 Culik, B., Adelung, D., and Woakes, A. J. (1995). Penguins disturbed by tourists.  
 525 *Nature* **376**, 301-302.  
 526 Dandenong Valley Authority (1979). Edithvale Wetlands Buffer Area Analysis.  
 527 *Dandenong Valley Authority Environmental Report 2*.  
 528 Davidson, N. C., and Rothwell, P. (1993). 'Disturbance to Waterfowl on Estuaries.'  
 529 (Wader Study Group: Thetford, U. K.)  
 530 Davies, P. M., and Lane, J. A. K. (1995). 'Guidelines for design of effective buffers  
 531 for wetlands on the Swan Coastal Plain ' (Australian Nature Conservation  
 532 Agency: Canberra, Australia.)  
 533 Delaney, D. K., Grubb, T. G., Beier, P., Pater, L. L., and Reiser, M. H. (1999). Effects  
 534 of helicopter noise on Mexican Spotted Owls. *Journal of Wildlife Management*  
 535 **63**, 60-76.  
 536 Dill, L. M. (1990). Distance-to-cover and the escape decision of an African cichlid  
 537 fish, *Melanochromis chipokae*. *Environmental Biology of Fishes* **27**, 147-152.  
 538 Dowling, B., and Weston, M. A. (1999). Managing the Hooded Plover in a high-use  
 539 recreational environment. *Bird Conservation International* **9**, 255-270.  
 540 Dunning, J. B. (2008). 'CRC Handbook of Avian Body Masses. Second Edition.' (CRC  
 541 Press: New York, USA.)  
 542 Fernández-Juricic, E., Blumstein, D. T., Abrica, G., Manriquez, L., Adams, L. B.,  
 543 Adams, R., Daneshard, M., and Rodriguez-Prieto, I. (2006). Effects of body  
 544 mass, size, and morphology on anti-predator escape and post-escape  
 545 responses: a comparative study with birds. *Evolutionary Ecology Research* **8**,  
 546 731-752.  
 547 Fernández-Juricic, E., Jimenez, M. D., and Lucas, E. (2001). Alert distance as an  
 548 alternative measure of bird tolerance to human disturbance: Implications for  
 549 park design. *Environmental Conservation* **28**, 263-269.  
 550 Fernández-Juricic, E., Jimenez, M. D., and Lucas, E. (2002). Factors affecting intra-  
 551 and inter-specific variations in the difference between alert distance and flight  
 552 distances for birds in forested habitats. *Canadian Journal of Zoology* **80**, 1212-  
 553 1220.  
 554 Fernández-Juricic, E., Vernier, M. P., Renison, D., and Blumstein, D. T. (2005).  
 555 Sensitivity of wildlife to spatial patterns of recreationist behavior: A critical  
 556 assessment of minimum approaching distances and buffer areas for grassland  
 557 birds. *Biological Conservation* **125**, 225-235.  
 558 Flather, C. H., and Cordell, H. K. (1995). Outdoor recreation, historical and  
 559 anticipated trends. In 'Wildlife and Recreationists: Coexistence through  
 560 Management and Research'. (eds. R. L. Knight, K. J. Gutzwiller) pp. 3-16.  
 561 (Island Press: Washington DC.)  
 562 Flemming, S. P., Chiasson, R. D., Smith, P. C., Austin-Smith, P., and Bancroft, R. P.  
 563 (1988). Piping Plover status in Nova Scotia related to its reproductive and  
 564 behavioral responses to human disturbance. *Journal of Field Ornithology* **59**,  
 565 321-330.  
 566 Fong, T. E., DeLong, T. W., Hogan, S. B., and Blumstein, D. T. (2009). The  
 567 importance of indirect cues in White-browed Sparrow-weaver (*Plocepasser*  
 568 *mahali*) risk assessment. *Acta Ethologica* **12**, 79-85.

- 569 Fox, A. D., and Madsen, J. (1997). Behavioural and distributional effects of hunting  
570 disturbance on waterbirds in Europe: implications for refuge design. *Journal*  
571 *of Applied Ecology* **34**, 1-13.
- 572 Fruziski, B. (1977). Feeding habits of Pink-footed Geese (*Anser fabalis*  
573 *brachyrhynchus*) in Denmark during the spring passage in April 1975. *Danish*  
574 *Review of Game Biology* **10**, 1-11.
- 575 Gabrielsen, G., Kanwisher, J., and Steen, J. B. (1977). Emotional bradycardia: a  
576 telemetry study on incubating Willow Grouse (*Lagopus lagopus*). *Acta*  
577 *Physiologica Scandinavica* **100**, 255-257.
- 578 Garamszegi, L. Z., Eens, M., and Török, J. (2009). Behavioural syndromes and  
579 trappability in free-living Collared Flycatchers, *Ficedulla albicollis*. *Animal*  
580 *Behaviour* **77**, 803-812.
- 581 Gates, J. E., and Gysel, L. W. (1978). Avian nest dispersion and fledging success in  
582 field-forest ecotones. *Ecology* **59**, 871-883.
- 583 Geist, C., Liao, J., Libby, S., and Blumstein, D. T. (2005). Does intruder group size  
584 and orientation affect flight initiation distance in birds? *Animal Biodiversity*  
585 *and Conservation* **28**, 68-73.
- 586 Gill, J. A., Sutherland, W. J., and Watkinson, A. R. (1996). A method to quantify the  
587 effects of human disturbance on animal populations. *Journal of Applied*  
588 *Ecology* **33**, 786-792.
- 589 Glover, H. K. (2009). Response Distances of Shorebirds to Disturbance: Towards  
590 Meaningful Buffers. Honours Thesis, Deakin University, Burwood, Australia.
- 591 Glover, H. K., Weston, M. A., and Maguire, G. S. (2011). Towards ecologically  
592 meaningful and socially acceptable buffers: Response distances of shorebirds  
593 in Victoria, Australia, to human disturbance. *Landscape and Urban Planning*  
594 **103**, 326-334.
- 595 Goss-Custard, J. D., and Verboven, N. (1993). Disturbance and feeding shorebirds on  
596 the Exe Estuary. In 'Disturbance to Waterfowl on Estuaries'. (eds. N.  
597 Davidson, P. Rothwell) pp. 59-66. (Wader Study Group: Thetford, U. K.)
- 598 Gould, M. L., Green, L., Altenau, B., and Blumstein, D. T. (2004). A study of the  
599 species-confidence hypothesis with Spiny-cheeked Honeyeaters  
600 (*Acanthagenys rufogularis*). *Emu* **104**, 267-271.
- 601 Gulbransen, D., Segrist, T., Del Castillo, P., and Blumstein, D. T. (2006). The fixed  
602 slope rule: An inter-specific study. *Ethology* **112**, 1056-1061.
- 603 Gutzwiller, K. J., and Marcum, H. A. (1993). Avian responses to observer clothing  
604 color: Caveats from winter point counts. *Wilson Bulletin* **105**, 628-636.
- 605 Hediger, H. (1934). Zur Biologie und Psychologie der Flucht bei Tieren. *Biologisches*  
606 *Zentralblatt* **54**, 21-40.
- 607 Heil, L., Fernández-Juricic, E., Renison, D., Nguyen, V., Cingolani, A. M., and  
608 Blumstein, D. T. (2007). Avian responses to tourism in the biogeographically  
609 isolated high Córdoba Mountains, Argentina. *Biodiversity and Conservation*  
610 **16**, 1009-1026.
- 611 Higgins, P. J. and various authors (1990 - 2006). Handbook of Australian, New  
612 Zealand and Antarctic Birds. Volumes 1-7. (Oxford University Press:  
613 Melbourne, Australia.)
- 614 Hill, D., Hockin, D., Price, D., Tucker, G., Morris, R., and Treweek, J. (1997). Bird  
615 disturbance: improving the quality and utility of disturbance research. *Journal*  
616 *of Applied Ecology* **34**, 275-288.

- 617 Hilton, G. M., Cresswell, W., and Ruxton, G. D. (1999). Intraflock variation in the  
618 speed of escape-flight response on attack by an avian predator. *Behavioral*  
619 *Ecology* **10**, 391-395.
- 620 Hingee, M., and Magrath, R. D. (2009). Flights of fear: a mechanical wing whistle  
621 sounds the alarm in a flocking bird. *Proceedings of the Royal Society of*  
622 *London Series B-Biological Sciences* **276**, 4173-4179.
- 623 Hockin, D., Ounsted, M., Gorman, M., Hill, D., Keller, V., and Barker, M. A. (1992).  
624 Examination of the effects of disturbance on birds with reference to its  
625 importance in ecological assessments. *Journal of Environmental Management*  
626 **36**, 253-286.
- 627 Holmes, T. L., Knight, R. L., Stegall, L., and Craig, G. R. (1993). Responses of  
628 wintering grassland raptors to human disturbance. *Wildlife Society Bulletin* **21**,  
629 461-468.
- 630 Ikuta, L. A., and Blumstein, D. T. (2003). Do fences protect birds from human  
631 disturbance? *Biological Conservation* **112**, 447-452.
- 632 Jorden, C. (2007). Flight Initiation Distance in Jackdaws (*Corvus monedula*) is  
633 Dependent on Predators Approach Speed and Height. Unpubl. Practical  
634 Report, University of Bristol, Bristol, UK.
- 635 Kanwisher, J. W., Williams, T. C., Teal, J. M., and Lawson, K. O. (1978).  
636 Radiotelemetry of heart rates from free-ranging gulls. *Auk* **95**, 288-293.
- 637 Keller, V. (1989). Variations in the response of Great Crested Grebes *Podiceps*  
638 *cristatus* to human disturbance – a sign of adaptation? *Biological*  
639 *Conservation* **49**, 31-45.
- 640 Kirby, J. S., Clee, C., and Seager, V. (1993). Impact and extent of recreational  
641 disturbance to wader roosts on the Dee estuary: some preliminary results. In  
642 'Disturbance to Waterfowl on Estuaries'. (eds. N. Davidson, P. Rothwell) pp.  
643 53-66. (Wader Study Group: Thetford, U. K.)
- 644 Kitchen, K., Lill, A., and Price, M. (2010). Tolerance of human disturbance by urban  
645 Magpie-larks. *Australian Field Ornithology* **27**, 1-9.
- 646 Kushlan, J. A. (1979). Effects of helicopter census on wading bird colonies. *Journal*  
647 *of Wildlife Management* **43**, 756-760.
- 648 Lane, B. (2003). 'Disturbance Distances for Wetland Birds - A Literature Review.'  
649 (Unpublished report to the Kingston City Council by Brett Lane and  
650 Associates Pty Ltd: Mansfield, Australia.)
- 651 Lima, S. L., and Bednekoff, P. A. (1999). Back to the basics of antipredator vigilance:  
652 can nonvigilant animals detect attacks? *Animal Behaviour* **58**, 537-543.
- 653 Marchant, S., and Higgins, P. J. (1993). 'Handbook of Australian, New Zealand and  
654 Antarctic Birds. Volume 2. Raptors to Lapwings.' (Oxford University Press:  
655 Melbourne, Australia.)
- 656 Metcalfe, N. B. (1983). The effects of mixed-species flocking on the vigilance of  
657 shorebirds: Who do they trust? *Animal Behaviour* **32**, 986-993.
- 658 Møller, A. P. (2008). Flight distance and population trends in European breeding  
659 birds. *Behavioral Ecology* **19**, 1095-1102.
- 660 Møller, A. P. (2010). Up, up and away: Relative importance of horizontal and vertical  
661 escape from predators for survival and senescence. *Journal of Evolutionary*  
662 *Biology* **23**, 1689-1698.
- 663 Møller, A. P., and Erritzøe, J. (2010). Flight distance and eye size in birds. *Ethology*  
664 **116**, 458-465.



- 665 Møller, A. P., and Garamszegi, L. Z. (2012). Between individual variation in risk-  
666 taking behavior and its life history consequences. *Behavioural Ecology*  
667 doi:10.1093/beheco/ars040.
- 668 Monie, L. (2011). Factors Affecting Alert Distance and Flight-initiation Distance in  
669 Black Swans (*Cygnus atratus*) at Albert Park Lake, Victoria, Australia. Third  
670 Year Research Thesis, Victoria University, St-Albans, Australia.
- 671 Nimon, A. J., Schroter, R. C., and Oxenham, R. K. (1996). Artificial eggs: measuring  
672 heart rate and effects of disturbance in nesting penguins. *Physiology and*  
673 *Behavior* **60**, 1019-1022.
- 674 Nimon, A. J., Schroter, R. C., and Stonehouse, B. (1995). Heart rate of disturbed  
675 penguins. *Nature* **374**.
- 676 Page, G. W., Stenzel, L. E., Winkler, D. W., and Swarth, C. W. (1983). Spacing out at  
677 Mono Lake: breeding success, nest density, and predation in the Snowy  
678 Plover. *Auk* **100**, 13-24.
- 679 Paton, D. C., Ziembicki, M., Owen, P., and Heddle, C. (2000). Disturbance Distances  
680 for Water Birds and the Management of Human Recreation with Special  
681 Reference to the Coorong Region of South Australia. (University of Adelaide:  
682 Adelaide, Australia.)
- 683 Pease, M. L., Rose, R. K., and Butler, M. J. (2005). Effects of human disturbances on  
684 the behavior of wintering ducks. *Wildlife Society Bulletin* **33**, 103-112.
- 685 Price, M. (2003). Tolerance of a Human Observer by Four Ground-foraging Bird  
686 Species in Urban and Rural Areas. Honours Thesis, Monash University,  
687 Clayton, Australia.
- 688 Price, M. (2008). The impact of human disturbance on birds: a selective review. In  
689 'Too Close for Comfort: Contentious Issues in Human-Wildlife Encounters'.  
690 (eds. D. Lunney, A. Munn, W. Meikle) pp. 163-196. (Royal Zoological  
691 Society of New South Wales: Mosman, Australia.)
- 692 Randler, C. (2005). Coots *Fulica atra* reduce their vigilance under increased  
693 competition. *Behavioural Processes* **68**, 173-178.
- 694 Regel, J., and Pütz, K. (1997). Effect of human disturbance on body temperature and  
695 energy expenditure in penguins. *Polar Biology* **18**, 246-253.
- 696 Roberts, G. (1996). Why individual vigilance declines as group size increases. *Animal*  
697 *Behaviour* **51**, 1077-1086.
- 698 Rodgers, J. A., and Smith, H. T. (1995). Set-back distances to protect nesting bird  
699 colonies from human disturbance in Florida. *Conservation Biology* **9**, 89-99.
- 700 Sekercioglu, C. H. (2002). Impacts of birdwatching on human and avian communities.  
701 *Environmental Conservation* **29**, 282-289.
- 702 Stalmaster, M. V., and Newman, J. R. (1978). Behavioural responses of wintering  
703 Bald Eagles to human activity. *Journal of Wildlife Management* **42**, 506-513.
- 704 Stankowich, T., and Blumstein, D. T. (2005). Fear in animals: A meta-analysis and  
705 review of risk assessment. *Proceedings of the Royal Society of London Series*  
706 *B-Biological Sciences* **272**, 2627-2634.
- 707 Taylor, I. R. (2006). Managing visitor disturbance of waterbirds on Australian inland  
708 wetlands. In 'Wetlands of the Murrumbidgee River Catchment: Practical  
709 Management in an Altered Environment'. (eds. I. R. Taylor, P. A. Murray, S.  
710 G. Taylor) pp. 150-157. (Fivebough and Tuckerbil Wetlands Trust: Leeton,  
711 Australia.)

- Thiel, D., Ménoni, E., Brenot, J.-F., and Jenni, L. (2007). Effects of recreation and hunting on flushing distance of Capercaillie. *Journal of Wildlife Management* **71**, 1784-1792.
- Van Der Zande, A. N., and Verstrael, T. J. (1985). Impacts of outdoor recreation upon nest-site choice and breeding success of the Kestrel. *Ardea* **73**, 90-99.
- Vos, D. K., Ryder, R. A., and Graul, W. D. (1985). Response of breeding Great Blue Herons to human disturbance in Northcentral Colorado. *Colonial Waterbirds* **8**, 13-22.
- Walker, B. G., Boersma, P. D., and Wingfield, J. C. (2006). Habituation of adult Magellanic Penguins to human visitation as expressed through behavior and corticosterone secretion. *Conservation Biology* **20**, 146-154.
- Ward, D. H., Stehn, R. A., and Derksen, D. V. (1994). Response of staging Brant to disturbance at the Izembek Lagoon, Alaska. *Wildlife Society Bulletin* **22**, 220-228.
- Watson, A. (1988). Dotterel *Charadrius morinellus* numbers in relation to human impact in Scotland. *Biological Conservation* **43**, 245-256.
- Weimerskirch, H., Shaffer, S. A., Mabile, G., Martin, J., Boutard, O., and Rouanet, J. L. (2002). Heart rate and energy expenditure of incubating Wandering Albatrosses: Basal levels, natural variation, and the effects of human disturbance. *Journal of Experimental Biology* **205**, 475-483.
- Weston, M. A., Antos, M. J., and Glover, H. K. (2009). Birds, buffers and bicycles: a review and case study of wetland buffers. *Victorian Naturalist* **126**, 79-86.
- Weston, M. A., Ehmke, G., and Maguire, G. S. (2011). Nest return times in response to static versus mobile human disturbance. *Journal of Wildlife Management* **75**, 252-255.
- Weston, M. A., and Elgar, M. A. (2005). Disturbance to brood-rearing Hooded Plover *Thinornis rubricollis*: responses and consequences. *Bird Conservation International* **15**, 193-209.
- Weston, M. A., and Elgar, M. A. (2007). Responses of incubating Hooded Plovers (*Thinornis rubricollis*) to disturbance. *Journal of Coastal Research* **23**, 569-576.
- Williams, K. J., Weston, M. A., Henry, S., and Maguire, G. S. (2009). Birds and beaches, dogs and leashes: Dog owner's sense of obligation to leash dogs on beaches in Victoria, Australia. *Human Dimension of Wildlife* **14**, 89-101.
- Wilson, R. P., Culik, B., Danfeld, R., and Adelung, D. (1991). People in Antarctica – how much do Adélie Penguins *Pygoscelis adeliae* care? *Polar Biology* **11**, 363-370.
- Woodland, D. J., Jaafar, Z., and KnightSource, M.-L. (1980). "Pursuit deterrent" function of alarm signals. *The American Naturalist* **115**, 748-753.
- Yalden, D. W., and Yalden, P. E. (1989). The sensitivity of breeding Golden Plovers *Pluvialis apricaria* to human intruders. *Bird Study* **36**, 49-55.
- Ydenberg, R. C., and Dill, L. M. (1986). The economics of fleeing from predators. *Advances in the Study of Behavior* **16**, 229-249.

758 Table 1. Number and percentage of species in different taxonomic groups for which  
759 FID of Australian birds have been reported (Paton *et al.* 2000; Blumstein *et al.* 2003;  
760 Price 2003; Blakney 2004; Blumstein 2006; Taylor 2006; Kitchen *et al.* 2010; Glover  
761 *et al.* 2011; Monie 2011). Blanks indicate no FIDs have been located.

Order (family)	Stimulus				Percentage of species in group
	Walker	Dog	Boat	Canoe	
Casuariiformes					25.0
Casuariidae	1				25.0
Galliformes					30.8
Megapodiidae	2				66.7
Phasianidae	2				25.0
Anseriformes					35.7
Anatidae	10	1	2	1	37.0
Podicipediformes					50.0
Podicipedidae	2				50.0
Columbiformes					32.4
Columbidae	11				32.4
Caprimulgiformes					25.0
Podargidae	1				33.3
Eurostopodidae	1				50.0
Phalacrocoraciformes					29.4
Anhingidae	1				100.0
Phalacrocoracidae	4				57.1
Ciconiiformes					58.6
Pelecanidae	1				100.0
Ardeidae	11				50.0
Threskiornithidae	5		1	1	100.0
Accipitriformes					28.6
Accipitridae	6				28.6
Falconiformes					33.3
Falconidae	2				33.3
Gruiformes					25.0
Rallidae	6				28.6
Charadriiformes					33.6
Burhinidae	1				50.0
Haematopodidae	2				66.7
Recurvirostridae	3	2	3	3	100.0
Charadriidae	10				52.6

Scolopacidae	17	3	5	5	38.6
Turnicidae	1				14.3
Laridae	7				21.9
Psittaciformes					28.6
Cacatuidae	7				50.0
Psittacidae	9				22.0
Cuculiformes					31.3
Cuculidae	5				31.25
Coraciiformes					50.0
Alcedinidae	1				33.3
Halcyonidae	4				44.4
Meropidae	1				100.0
Coraciidae	1				100.0
Passeriformes					31.6
Menuridae	1				50.0
Climacteridae	3				50.0
Ptilonorhynchidae	4				40.0
Maluridae	3				13.6
Acanthizidae	16				38.1
Pardalotidae	1				25.0
Meliphagidae	24				32.4
Pomatostomidae	2				50.0
Orthonychidae	2				100.0
Eupetidae	1				12.5
Campephagidae	3				37.5
Pachycephalidae	5				35.7
Oriolidae	2				66.7
Artamidae	7				50.0
Dicruridae	1				100.0
Rhipiduridae	3				42.9
Corvidae	2				28.6
Monarchidae	5				35.7
Corcoracidae	2				100.0
Paradisaeidae	1				25.0
Petroicidae	5				22.7
Cisticolidae	1				50.0
Acrocephalidae	1				50.0
Megaluridae	2				40.0
Timaliidae	1				14.3
Hirundinidae	2				28.6
Pycnonotidae	1				100.0
Turdidae	3				60.0
Sturnidae	2				28.6

Nectariniidae	1	33.3
Estrildidae	5	23.8
Passeridae	2	100.0
Motacillidae	2	25.0
Fringillidae	3	75.0

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763

764 Table 2. Recommended fields for documenting Flight Initiation Distance data,  
 765 assuming basic methods are fully documented.



Aspect	Fields
Stimulus	Stimulus type (e.g. walker) and number of stimuli per approach Clothing colour Speed of approach Relative angle of approach (direct or tangential) Distance at which approach ceased (if required)
Response	SD (m) AD (m) if evident FID (m) if evident Type of escape (e.g. run, hide, swim, dive) Relative direction of escape Distance at which escape behaviour ceases
Context	Flock size and composition (e.g. number of conspecifics within 10 and 50 m) Age Sex Life history stage (e.g. non-breeding) Barriers (e.g. fences, channels) Height (m) if perched Starting behaviour Substrate Weather particularly wind speed and direction

Date, location (including tenure and indices of human presence),  
species/subspecies being approached

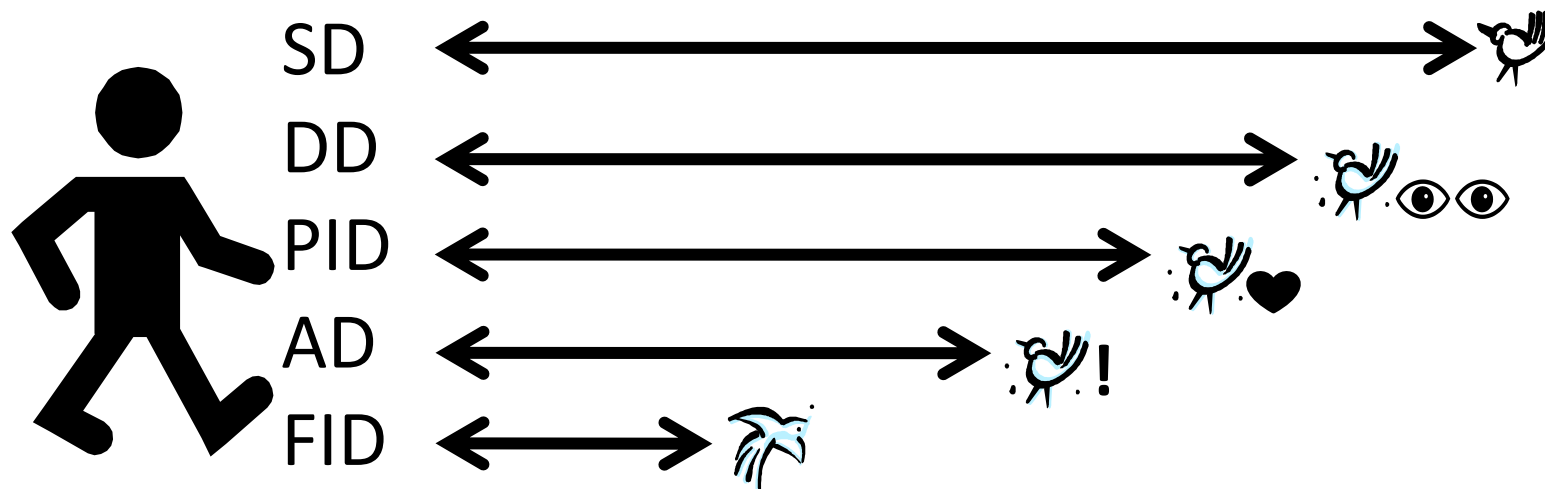
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766

767 Figure 1. Visual representation of the Detection Distance (DD; ) , Physiological Initiation Distance (PID; ) , Alarm

768 Initiation Distance (AD; ) ) and Flight Initiation Distance (FID; ) . Presented to illustrate a conceptual framework; distances are  
769 not to scale.

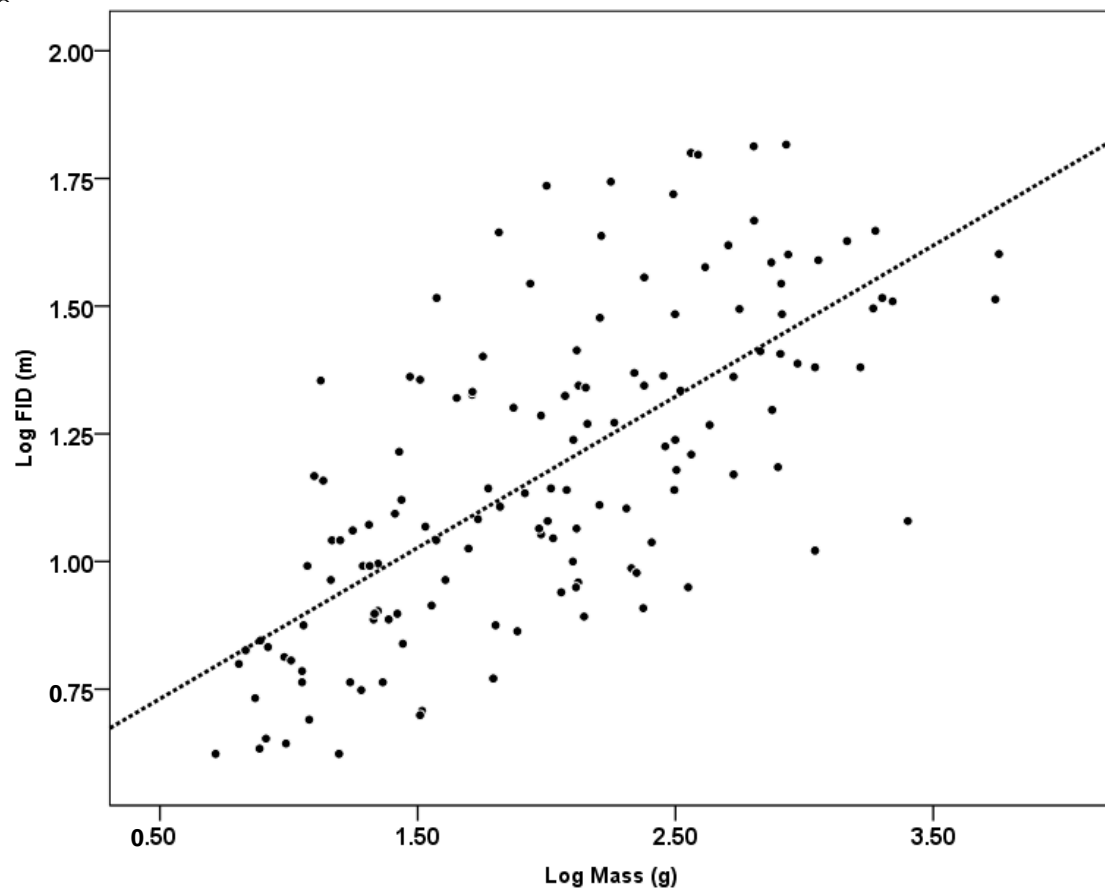
770



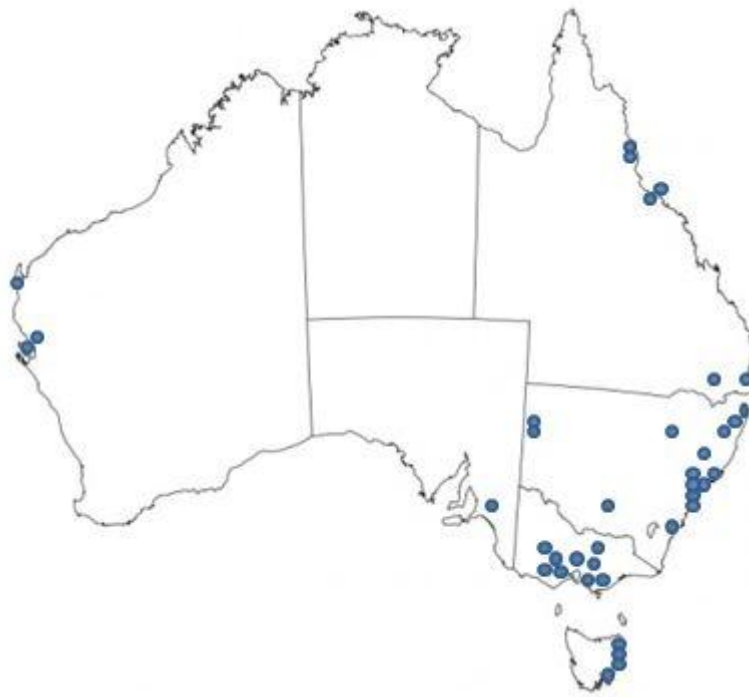
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Figure 2. Linear regression of mean FIDs (from Appendix 1, where  $n \geq 10$ ), on mean body mass (g; averaged across sexes and Australian masses only; Dunning 2008 supplemented with Higgins *et al.* 1990-2006). Residual values and ranks are presented in Appendix 1.



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Figure 2. Locations in Australia where substantial numbers of FIDs have been

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reported (Paton *et al.* 2000; Blumstein *et al.* 2003; Price 2003; Blakney 2004; Gould

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*et al.* 2004; Cárdenas *et al.* 2005; Adams *et al.* 2006; Boyer *et al.* 2006; Taylor 2006;

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Kitchen *et al.* 2010; Monie 2011). Many FIDs are not associated with locations that

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could be mapped, and incidental collections of small numbers of FIDs have been

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omitted.

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Appendix 1. Available Flight Initiation Distances for birds in Australia (including introduced species) from published sources plus a partly unpublished database provided by DTB. Each row represents the FIDs reported by separate studies or in relation to treatment variables used in studies e.g., different habitats (thus, some taxa are in multiple rows). Only cited figures are presented, data have not been estimated from graphical presentation of results in source documents. Sources were: 1) Blumstein (2006); 2) Monie (2011); 3) Paton *et al.* (2000); 4) Taylor (2006); 5) Glover *et al.* (2011); 6) Blakney (2004); 7) Price (2003); 8) Kitchen *et al.* (2010); 9) Blumstein *et al.* (2003); 10) D. T. Blumstein Unpubl. Data; 11) Dandenong Valley Authority (1979). Residual values (and ranks, where 1 is the highest positive residual value) are also presented (see Fig. 2 and text), with highly positive values indicating FIDs substantially above that predicted by body mass, highly negative values indicating FIDs substantially below that predicted by body mass.

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Casuariidae	Emu	<i>Dromaius novaehollandiae</i>	58.7	36.2	6	118.1		10
Megapodiidae	Australian Brush Turkey	<i>Alectura lathamii</i>	12.0	13.0	11	33.4	-0.51 (140)	1
Megapodiidae	Orange-footed Scrubfowl	<i>Megapodius reinwardt</i>	25.9	8.8	4	40.4		10
Phasianidae	Stubble Quail	<i>Coturnix pectoralis</i>	1.9	0.5	2	2.8		10
Phasianidae	Brown Quail	<i>Coturnix ypsilophora</i>	5.5	4.7	5	13.1		10
Anatidae	Musk Duck	<i>Biziura lobata</i>	18.9	1.5	2	21.4		10
Anatidae	Black Swan	<i>Cygnus atratus</i>	50.4	35.8	19	109.3		1
Anatidae	Black Swan	<i>Cygnus atratus</i>	3.6	3.8	92	9.9	-0.09 (89)	2
Anatidae	Black Swan <sup>^</sup>	<i>Cygnus atratus</i>	149.0	0.0	1	149.0		3
Anatidae	Black Swan <sup>^2</sup>	<i>Cygnus atratus</i>	113.0	0.0	1	113.0		3
Anatidae	Black Swan	<i>Cygnus atratus</i>	n/a	n/a	90	159		4
Anatidae	Black Swan	<i>Cygnus atratus</i>	40.0		n/a			11
Anatidae	Black Swan <sup>1</sup>	<i>Cygnus atratus</i>	53.0		n/a			11
Anatidae	Australian Shelduck <sup>^</sup>	<i>Tadorna tadornoides</i>	145.0	0.0	1	145.0		3
Anatidae	Australian Shelduck	<i>Tadorna tadornoides</i>	n/a	n/a	35	270		4
Anatidae	Australian Wood Duck	<i>Chenonetta jubata</i>	25.5	24.9	44	66.5	-0.04 (74)	1
Anatidae	Australasian Shoveler	<i>Anas rhynchotis</i>	19.2	0.0	1	19.2		10
Anatidae	Grey Teal	<i>Anas gracilis</i>	41.6	22.8	23	79.1	0.24 (24)	1

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Anatidae	Grey Teal <sup>^</sup>	<i>Anas gracilis</i>	106.9	10.1	2	123.5		3
Anatidae	Grey Teal <sup>^2</sup>	<i>Anas gracilis</i>	59.0	8.5	2	73.0		3
Anatidae	Grey Teal <sup>^3</sup>	<i>Anas gracilis</i>	49.5		1			3
Anatidae	Grey Teal	<i>Anas gracilis</i>	n/a	n/a	72	330		4
Anatidae	Chestnut Teal	<i>Anas castanea</i>	46.5	21.4	55	81.7	0.25 (18)	1
Anatidae	Chestnut Teal	<i>Anas castanea</i>	n/a	n/a	20	260		4
Anatidae	Northern Mallard	<i>Anas platyrhynchos</i>	12.8	5.0	3	21.1		10
Anatidae	Pacific Black Duck	<i>Anas superciliosa</i>	38.9	29.0	50	86.6	0.1 (41)	1
Anatidae	Pacific Black Duck	<i>Anas superciliosa</i>	n/a	n/a	28	205		4
Anatidae	Hardhead	<i>Aythya australis</i>	37.1	20.9	9	71.5		10
Podicipedidae	Australasian Grebe	<i>Tachybaptus novaehollandiae</i>	23.4	14.1	19	46.6	0.09 (46)	1
Podicipedidae	Hoary-headed Grebe	<i>Poliocephalus poliocephalus</i>	23.8	7.3	4	35.8		10
Columbidae	White-headed Pigeon	<i>Columba leucomela</i>	26.0	34.5	2	82.7		10
Columbidae	Spotted Dove	<i>Streptopelia chinensis</i>	12.9	9.0	52	27.7	-0.13 (100)	1
Columbidae	Brown Cuckoo-dove	<i>Macropygia amboinensis</i>	8.1	4.8	11	16.0	-0.38 (137)	1
Columbidae	Emerald Dove	<i>Chalcophaps indica</i>	14.2	8.8	2	28.7		10
Columbidae	Common Bronzewing	<i>Phaps chalcoptera</i>	21.6	9.1	21	36.6	0.01 (61)	10
Columbidae	Crested Pigeon	<i>Ocyphaps lophotes</i>	12.7	9.2	31	27.8	-0.16 (109)	1
Columbidae	Peaceful Dove	<i>Geopelia striata</i>	12.1	7.8	27	24.9	-0.01 (67)	10
Columbidae	Bar-shouldered Dove	<i>Geopelia humeralis</i>	22.1	14.8	93	46.4	0.13 (32)	1
Columbidae	Wonga Pigeon	<i>Leucosarcia picata</i>	18.5	10.9	22	36.4	-0.09 (90)	1
Columbidae	Pied Imperial-pigeon	<i>Ducula bicolor</i>	21.5	11.3	4	40.1		10
Columbidae	Topknot Pigeon	<i>Lopholaimus antarcticus</i>	15.0	7.2	6	26.7		10
Podargidae	Tawny Frogmouth	<i>Podargus strigoides</i>	6.2	4.4	2	13.3		10
Eurostopodidae	Spotted Nightjar	<i>Eurostopodus argus</i>	10.8	0.0	1	10.8		10
Anhingidae	Australasian Darter	<i>Anhinga novaehollandiae</i>	24.0	14.9	20	48.5	-0.15 (108)	1
Phalacrocoracidae	Little Pied Cormorant	<i>Microcarbo melanoleucos</i>	19.8	14.3	58	43.3	-0.14 (105)	1
Phalacrocoracidae	Great Cormorant	<i>Phalacrocorax carbo</i>	32.3	20.6	34	66.2	-0.06 (81)	1
Phalacrocoracidae	Little Black Cormorant	<i>Phalacrocorax sulcirostris</i>	24	15.3	38	49.2	-0.1 (94)	1
Phalacrocoracidae	Pied Cormorant	<i>Phalacrocorax varius</i>	31.3	18.0	25	60.9	-0.05 (77)	1

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Pelecanidae	Australian Pelican	<i>Pelecanus conspicillatus</i>	32.6	25.4	39	74.4	-0.18 (112)	1
Ardeidae	Australasian Bittern	<i>Botaurus poiciloptilus</i>	10.0	0.0	1	10.0		10
Ardeidae	Australian Little Bittern	<i>Ixobrychus dubius</i>	12.9	4.5	4	20.2		10
Ardeidae	White-necked Heron	<i>Ardea pacifica</i>	n/a	n/a	26	170		4
Ardeidae	White-necked Heron	<i>Ardea pacifica</i>	45.3	36.9	2	106.0		10
Ardeidae	Eastern Great Egret	<i>Ardea modesta</i>	39.9	24.8	79	80.7	0.15 (31)	1
Ardeidae	Eastern Great Egret	<i>Ardea modesta</i>	n/a	n/a	31	155.0		4
Ardeidae	Intermediate Egret	<i>Ardea intermedia</i>	n/a	n/a	27	210.0		4
Ardeidae	Intermediate Egret	<i>Ardea intermedia</i>	42.7	36.9	4	103.4		10
Ardeidae	Cattle Egret	<i>Ardea ibis</i>	63.1	46.8	11	140.1	0.46 (5)	10
Ardeidae	Striated Heron	<i>Butorides striata</i>	31.7	18.9	8	62.83		10
Ardeidae	White-faced Heron	<i>Egretta novaehollandiae</i>	31.2	20.1	33	64.3	0.1 (44)	1
Ardeidae	White-faced Heron	<i>Egretta novaehollandiae</i>	n/a	n/a	25	215		4
Ardeidae	Little Egret	<i>Egretta garzetta</i>	52.4	23.0	10	90.2	0.4 (10)	1
Ardeidae	Eastern Reef Egret	<i>Egretta sacra</i>	31.1	13.6	2	53.5		10
Ardeidae	Nankeen Night-heron	<i>Nycticorax caledonicus</i>	16.6	5.8	4	26.1		10
Threskiornithidae	Glossy Ibis	<i>Plegadis falcinellus</i>	n/a	n/a	35	195		4
Threskiornithidae	Glossy Ibis	<i>Plegadis falcinellus</i>	83.1	0.0	1	83.1		10
Threskiornithidae	Australian White Ibis	<i>Threskiornis molucca</i>	32.8	20.4	48	66.4	-0.04 (76)	1
Threskiornithidae	Australian White Ibis <sup>^</sup>	<i>Threskiornis molucca</i>	80.8	2.5	2	84.9		3
Threskiornithidae	Australian White Ibis <sup>^2</sup>	<i>Threskiornis molucca</i>	62.2	26.2	3	105.3		3
Threskiornithidae	Australian White Ibis <sup>^3</sup>	<i>Threskiornis molucca</i>	58.3	37.8	2	120.5		3
Threskiornithidae	Australian White Ibis	<i>Threskiornis molucca</i>	n/a	n/a	20	130.0		4
Threskiornithidae	Straw-necked Ibis	<i>Threskiornis spinicollis</i>	42.4	25.2	10	83.9	0.11 (39)	1
Threskiornithidae	Straw-necked Ibis	<i>Threskiornis spinicollis</i>	n/a	n/a	15	135.0		4
Threskiornithidae	Royal Spoonbill	<i>Platalea regia</i>	44.4	24.9	24	85.4	0.1 (45)	1
Threskiornithidae	Royal Spoonbill	<i>Platalea regia</i>	n/a	n/a	25	70.0		4
Threskiornithidae	Yellow-billed Spoonbill	<i>Platalea flavipes</i>	n/a	n/a	24	80.0		4
Threskiornithidae	Yellow-billed Spoonbill	<i>Platalea flavipes</i>	51.0	41.5	4	119.2		10
Accipitridae	Black-shouldered Kite	<i>Elanus axillaris</i>	23.1	14.9	10	47.6	0.05 (50)	1

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Accipitridae	Pacific Baza	<i>Aviceda subcristata</i>	18.0	0.0	1	18.0		10
Accipitridae	Whistling Kite	<i>Haliastur sphenurus</i>	28.2	12.3	3	48.5		10
Accipitridae	Black Kite	<i>Milvus migrans</i>	57.0	0.0	1	57.0		10
Accipitridae	Grey Goshawk	<i>Accipiter novaehollandiae</i>	24.6	0.0	1	24.6		10
Accipitridae	Spotted Harrier	<i>Circus assimilis</i>	22.0	0.0	1	22.0		10
Falconidae	Nankeen Kestrel	<i>Falco cenchroides</i>	43.4	44.1	14	116.0	0.4 (9)	10
Falconidae	Brown Falcon	<i>Falco berigora</i>	34.1	28.1	2	80.3		10
Rallidae	Purple Swampphen	<i>Porphyrio porphyrio</i>	34.5	21.8	68	70.4	0.4 (8)	1
Rallidae	Purple Swampphen	<i>Porphyrio porphyrio</i>	65.0	0.0	n/a	65.0		11
Rallidae	Lewin's Rail	<i>Lewinia pectoralis</i>	4.3	0.0	1	4.3		10
Rallidae	Buff-banded Rail	<i>Gallirallus philippensis</i>	8.0	0.0	1	8.0		10
Rallidae	Baillon's Crake	<i>Porzana pusilla</i>	8.2	4.6	3	15.8		10
Rallidae	Dusky Moorhen	<i>Gallinula tenebrosa</i>	14.8	10.7	37	32.4	-0.22 (120)	1
Rallidae	Eurasian Coot	<i>Fulica atra</i>	19.2	15.8	10	45.2	-0.03 (73)	1
Rallidae	Eurasian Coot	<i>Fulica atra</i>	23.0	0.0	n/a	23.0		11
Burhinidae	Bush Stone-curlew	<i>Burhinus grallarius</i>	25.9	20.7	13	59.9	-0.01 (64)	1
Haematopodidae	Australian Pied Oystercatcher	<i>Haematopus longirostris</i>	38.5	18	23	68.1	0.15 (30)	1
Haematopodidae	Australian Pied Oystercatcher^	<i>Haematopus longirostris</i>	82.5	64.4	2	188.4		3
Haematopodidae	Australian Pied Oystercatcher	<i>Haematopus longirostris</i>	41.5	16.2	21	68.1		5
Haematopodidae	Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	30.5	15.8	59	56.5	0.04 (52)	1
Haematopodidae	Sooty Oystercatcher	<i>Haematopus fuliginosus</i>	64.3	43.1	14	135.1		5
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	38.3	21.1	63	73	0.24 (21)	1
Recurvirostridae	Black-winged Stilt^	<i>Himantopus himantopus</i>	39.3	22.9	3	77		3
Recurvirostridae	Black-winged Stilt^1	<i>Himantopus himantopus</i>	43.5	15.0	2	68.0		3
Recurvirostridae	Black-winged Stilt^2	<i>Himantopus himantopus</i>	33.5	2.1	2	37.0		3
Recurvirostridae	Black-winged Stilt^3	<i>Himantopus himantopus</i>	35.8	14.5	2	59.7		3
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	n/a	n/a	42	80		4
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	38.0	16.7	20	65.4		5
Recurvirostridae	Black-winged Stilt	<i>Himantopus himantopus</i>	30.0	0.0	n/a	30.0		11
Recurvirostridae	Red-necked Avocet^	<i>Recurvirostra novaehollandiae</i>	60.4	7.8	3	73.2		3

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Recurvirostridae	Red-necked Avocet <sup>2</sup>	<i>Recurvirostra novaehollandiae</i>	57.0	0.0	1	57.0		3
Recurvirostridae	Red-necked Avocet <sup>3</sup>	<i>Recurvirostra novaehollandiae</i>	43.0	0.0	1	43.0		3
Recurvirostridae	Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	n/a	n/a	20.0	110.0		4
Recurvirostridae	Red-necked Avocet	<i>Recurvirostra novaehollandiae</i>	73.0	39.2	5	137.4		5
Recurvirostridae	Banded Stilt <sup>^</sup>	<i>Cladorhynchus leucocephalus</i>	32.8	23.7	8	71.8		3
Recurvirostridae	Banded Stilt <sup>1</sup>	<i>Cladorhynchus leucocephalus</i>	40.2	11.0	2	58.3		3
Recurvirostridae	Banded Stilt <sup>2</sup>	<i>Cladorhynchus leucocephalus</i>	28.8	8.1	4	42.1		3
Recurvirostridae	Banded Stilt <sup>3</sup>	<i>Cladorhynchus leucocephalus</i>	24.7	7.7	5	37.4		3
Charadriidae	Pacific Golden Plover	<i>Pluvialis fulva</i>	21.9	12.1	21	41.8	0.12 (34)	1
Charadriidae	Pacific Golden Plover	<i>Pluvialis fulva</i>	49.3	10.1	3	65.9		5
Charadriidae	Grey Plover	<i>Pluvialis squatarola</i>	36.0	18.7	41	66.8	0.27 (16)	1
Charadriidae	Grey Plover	<i>Pluvialis squatarola</i>	44.0	0.0	1	44.0		5
Charadriidae	Red-capped Plover	<i>Charadrius ruficapillus</i>	22.0	7.7	16	34.7		1
Charadriidae	Red-capped Plover	<i>Charadrius ruficapillus</i>	n/a	n/a	18	45.0		4
Charadriidae	Red-capped Plover	<i>Charadrius ruficapillus</i>	32.8	15.4	20	58.1	0.47 (4)	5
Charadriidae	Double-banded Plover	<i>Charadrius bicinctus</i>	32.1	7.5	7	44.5		5
Charadriidae	Double-banded plover	<i>Charadrius bicinctus</i>	13.9	6.1	10	23.8	0.04 (54)	10
Charadriidae	Lesser Sand Plover	<i>Charadrius mongolus</i>	16.7	7.7	7	29.4		10
Charadriidae	Black-fronted Dotterel	<i>Elseyaornis melanops</i>	22.7	9.3	46	37.9	0.33 (14)	1
Charadriidae	Black-fronted Dotterel	<i>Elseyaornis melanops</i>	23.9	8.2	17	37.3		5
Charadriidae	Hooded Plover	<i>Thinornis rubricollis</i>	54.4	35.4	30	112.7	0.56 (1)	6
Charadriidae	Hooded Plover	<i>Thinornis rubricollis</i>	41.1	17.1	8	69.3		5
Charadriidae	Hooded Plover	<i>Thinornis rubricollis</i>	26.3	3.3	4	31.6		10
Charadriidae	Red-kneed Dotterel	<i>Erythronyctes cinctus</i>	n/a	n/a	22	40.0		4
Charadriidae	Red-kneed Dotterel	<i>Erythronyctes cinctus</i>	21.2	6.2	10	31.3	0.24 (23)	5
Charadriidae	Red-kneed dotterel	<i>Erythronyctes cinctus</i>	15.4	1.5	2	17.8		10
Charadriidae	Banded Lapwing	<i>Vanellus tricolor</i>	74.0	0.0	1	74.0		5
Charadriidae	Masked Lapwing	<i>Vanellus miles</i>	46.8	30.5	37	96.9		1
Charadriidae	Masked Lapwing	<i>Vanellus miles</i>	62.6	43.1	55	133.5	0.45 (6)	5
Scolopacidae	Latham's Snipe	<i>Gallinago hardwickii</i>	18.6	9.6	30	34.5	0.05 (51)	5

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Scolopacidae	Latham's Snipe	<i>Gallinago hardwickii</i>	13.7	7.8	8	26.6		10
Scolopacidae	Black-tailed Godwit	<i>Limosa limosa</i>	31.3	3.3	4	36.7		5
Scolopacidae	Black-tailed Godwit	<i>Limosa limosa</i>	21.0	11.3	6	39.7		10
Scolopacidae	Bar-tailed Godwit <sup>^</sup>	<i>Limosa lapponica</i>	48.6	0.9	2	50.1		3
Scolopacidae	Bar-tailed Godwit <sup>^2</sup>	<i>Limosa lapponica</i>	53.5	7.8	2	66.3		3
Scolopacidae	Bar-tailed Godwit <sup>^3</sup>	<i>Limosa lapponica</i>	41.9	4.5	2	49.3		3
Scolopacidae	Bar-tailed Godwit	<i>Limosa lapponica</i>	59.5	10.5	4	76.8		5
Scolopacidae	Bar-tailed Godwit	<i>Limosa lapponica</i>	22.1	14.8	196	46.5	0.06 (49)	10
Scolopacidae	Whimbrel	<i>Numenius phaeopus</i>	37.7	30.4	28	87.7	0.22 (25)	1
Scolopacidae	Whimbrel	<i>Numenius phaeopus</i>	90.0	0.0	1	90.0		5
Scolopacidae	Eastern Curlew	<i>Numenius madagascariensis</i>	65.5	41.6	42	133.9	0.37 (12)	1
Scolopacidae	Eastern Curlew <sup>^</sup>	<i>Numenius madagascariensis</i>	97.5	23.3	2	135.8		3
Scolopacidae	Eastern Curlew	<i>Numenius madagascariensis</i>	126.1	29.2	22	174.2		5
Scolopacidae	Common Sandpiper	<i>Actitis hypoleucos</i>	43.0	0.0	1	43.0		5
Scolopacidae	Grey-tailed Tattler	<i>Tringa brevipes</i>	17.3	8.6	45	31.4	0.03 (56)	1
Scolopacidae	Grey-tailed Tattler	<i>Tringa brevipes</i>	23.0	0.0	1	23.0		5
Scolopacidae	Common Greenshank <sup>^</sup>	<i>Tringa nebularia</i>	70.0	11.8	3	89.4		3
Scolopacidae	Common Greenshank <sup>^1</sup>	<i>Tringa nebularia</i>	80.3	13.0	2	102.0		3
Scolopacidae	Common Greenshank <sup>^2</sup>	<i>Tringa nebularia</i>	60.7	4.0	3	67.3		3
Scolopacidae	Common Greenshank <sup>^3</sup>	<i>Tringa nebularia</i>	51.5	3.5	2	57.3		3
Scolopacidae	Common Greenshank	<i>Tringa nebularia</i>	n/a	n/a	17	75.0		4
Scolopacidae	Common Greenshank	<i>Tringa nebularia</i>	55.4	27.8	17	101.2	0.49 (3)	5
Scolopacidae	Common Greenshank	<i>Tringa nebularia</i>	47.6	17.8	7	77.0		10
Scolopacidae	Marsh Sandpiper	<i>Tringa stagnatilis</i>	n/a	n/a	20	105.0		4
Scolopacidae	Marsh Sandpiper	<i>Tringa stagnatilis</i>	44.1	23.2	20	82.3	0.52 (2)	5
Scolopacidae	Ruddy Turnstone	<i>Arenaria interpres</i>	13.8	6.4	51	24.3	-0.06 (78)	1
Scolopacidae	Ruddy Turnstone	<i>Arenaria interpres</i>	29.7	14.3	6	53.2		5
Scolopacidae	Short-billed Dowitcher <sup>**</sup>	<i>Limnodromus griseus</i>	12.7	6.2	11	22.9		1
Scolopacidae	Red Knot	<i>Calidris canutus</i>	21.3	9.2	8	36.4		10
Scolopacidae	Sanderling	<i>Calidris alba</i>	32.0	7.9	5	44.9		5



Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Scolopacidae	Red-necked Stint	<i>Calidris ruficollis</i>	16.4	8.7	61	30.7	0.21 (26)	1
Scolopacidae	Red-necked Stint <sup>^</sup>	<i>Calidris ruficollis</i>	20.0	3.5	4	25.8		3
Scolopacidae	Red-necked Stint <sup>^1</sup>	<i>Calidris ruficollis</i>	32.6	14.0	3	55.3		3
Scolopacidae	Red-necked Stint <sup>^2</sup>	<i>Calidris ruficollis</i>	28.1	1.8	3	31.1		3
Scolopacidae	Red-necked Stint <sup>^3</sup>	<i>Calidris ruficollis</i>	17.3	4.2	3	24.2		3
Scolopacidae	Red-necked Stint	<i>Calidris ruficollis</i>	18.7	8.7	23	33.0	0.16 (28)	5
Scolopacidae	Pectoral Sandpiper	<i>Calidris melanotos</i>	23.0	9.9	2	39.3		5
Scolopacidae	Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	14.8	8.7	28	29.1		1
Scolopacidae	Sharp-tailed Sandpiper <sup>^</sup>	<i>Calidris acuminata</i>	33.2	3.9	5	39.6		3
Scolopacidae	Sharp-tailed Sandpiper <sup>^1</sup>	<i>Calidris acuminata</i>	39.3	3.7	2	45.4		3
Scolopacidae	Sharp-tailed Sandpiper <sup>^2</sup>	<i>Calidris acuminata</i>	35.7	4.2	3	42.6		3
Scolopacidae	Sharp-tailed Sandpiper <sup>^3</sup>	<i>Calidris acuminata</i>	28.1	4.0	4	34.7		3
Scolopacidae	Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	n/a	n/a	30	55.0		4
Scolopacidae	Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	20.3	7.5	31	32.7		5
Scolopacidae	Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	20.0	0.0	n/a	20.0		11
Scolopacidae	Curlew Sandpiper <sup>^</sup>	<i>Calidris ferruginea</i>	34.8	6.0	4	44.7	0.3 (15)	3
Scolopacidae	Curlew Sandpiper <sup>^2</sup>	<i>Calidris ferruginea</i>	29.8	4.8	3	37.7		3
Scolopacidae	Curlew Sandpiper <sup>^3</sup>	<i>Calidris ferruginea</i>	26.8	2.9	3	31.6		3
Scolopacidae	Curlew Sandpiper	<i>Calidris ferruginea</i>	25.2	6.4	21	35.7		5
Scolopacidae	Curlew Sandpiper	<i>Calidris ferruginea</i>	24.9	6.0	8	34.8		10
Turnicidae	Red-chested Button-quail	<i>Turnix pyrrhothorax</i>	3.6	2.1	5	7.0	0.24 (20)	10
Laridae	Little Tern	<i>Sternula albifrons</i>	21.5	7.9	18	34.5		1
Laridae	Caspian Tern	<i>Hydroprogne caspia</i>	35.0	10.4	12	52.1	0.1 (43)	1
Laridae	Whiskered Tern	<i>Chlidonias hybrida</i>	21.4	8.5	3	35.3		10
Laridae	Common Tern	<i>Sterna hirundo</i>	20.5	10.9	8	38.4	-0.08 (86)	10
Laridae	Crested Tern	<i>Thalasseus bergii</i>	17.3	10.7	37	34.9		1
Laridae	Kelp Gull	<i>Larus dominicanus</i>	24.4	11.4	14	43.2		1
Laridae	Silver Gull	<i>Chroicocephalus novaehollandiae</i>	16.8	12.1	136	36.7		1
Cacatuidae	Red-tailed Black-cockatoo	<i>Calyptorhynchus banksii</i>	10.9	15.2	3	35.9		10
Cacatuidae	Yellow-tailed Black-cockatoo	<i>Calyptorhynchus funereus</i>	11.7	6.7	4	22.8	-0.09 (87)	10

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Cacatuidae	Gang-gang Cockatoo	<i>Callocephalon fimbriatum</i>	7.5	5.6	2	16.6		10
Cacatuidae	Galah	<i>Eolophus roseicapillus</i>	8.9	5.6	64	18.1	-0.39 (138)	1
Cacatuidae	Long-billed Corella	<i>Cacatua tenuirostris</i>	3.8	0.0	1	3.8		10
Cacatuidae	Little Corella	<i>Cacatua sanguinea</i>	20.0	15.2	8	45.0		10
Cacatuidae	Sulphur-crested Cockatoo	<i>Cacatua galerita</i>	15.3	14.9	41	39.8	-0.26 (126)	1
Psittacidae	Rainbow Lorikeet	<i>Trichoglossus haematodus</i>	10.0	8.1	11	23.3	-0.21 (116)	1
Psittacidae	Scaly-breasted Lorikeet	<i>Trichoglossus chlorolepidotus</i>	1.0	0.0	1	1.0		10
Psittacidae	Australian King Parrot	<i>Alisterus scapularis</i>	8.7	3.8	9	14.9		10
Psittacidae	Red-winged Parrot	<i>Aprosmictus erythropterus</i>	32.3	11.1	5	50.5		10
Psittacidae	Crimson Rosella	<i>Platycercus elegans</i>	9.1	6.4	83	19.6	-0.25 (124)	1
Psittacidae	Eastern Rosella	<i>Platycercus eximius</i>	13.9	8.8	31	28.4	-0.04 (75)	1
Psittacidae	Pale-headed Rosella	<i>Platycercus adscitus</i>	21.0	8.7	3	35.2		10
Psittacidae	Australian Ringneck	<i>Barnardius zonarius</i>	14.1	9.5	3	29.7		10
Psittacidae	Red-rumped Parrot	<i>Psephotus haematonotus</i>	11.2	6.6	9	22.1		10
Cuculidae	Pheasant Coucal	<i>Centropus phasianinus</i>	30.5	42.8	14	101.0	0.16 (29)	10
Cuculidae	Asian Koel**	<i>Eudynamys scolopaceus</i>	4.6	2.2	2	8.2		10
Cuculidae	Horsfield's Bronze-Cuckoo	<i>Chalcites basalis</i>	3.5	1.6	2	6.1		10
Cuculidae	Pallid Cuckoo	<i>Cacomantis pallidus</i>	8.5	1.1	2	10.3		10
Cuculidae	Fan-tailed Cuckoo	<i>Cacomantis flabelliformis</i>	10.6	5.7	19	19.9	-0.06 (79)	1
Alcedinidae	Azure Kingfisher	<i>Ceyx azureus</i>	11.7	4.5	10	19.1	0.03 (55)	10
Halcyonidae	Laughing Kookaburra	<i>Dacelo novaeguineae</i>	13.8	12.3	54	34.0	-0.18 (113)	1
Halcyonidae	Blue-winged Kookaburra	<i>Dacelo leachii</i>	23.0	0.0	1	23.0		10
Halcyonidae	Forest Kingfisher	<i>Todiramphus macleayii</i>	11.0	4.3	11	18.1	-0.01 (65)	10
Halcyonidae	Sacred Kingfisher	<i>Todiramphus sanctus</i>	20.9	6.8	16	32.1	0.25 (19)	1
Meropidae	Rainbow Bee-eater	<i>Merops ornatus</i>	23.0	17.8	10	52.3	0.34 (13)	10
Coraciidae	Dollarbird	<i>Eurystomus orientalis</i>	25.9	22.5	23	62.9	0.20 (27)	1
Menuridae	Superb Lyrebird	<i>Menura novaehollandiae</i>	10.5	8.6	26	24.6	-0.46 (139)	1
Climacteridae	White-throated Treecreeper	<i>Cormobates leucophaea</i>	5.8	2.9	17	10.6	-0.22 (121)	1
Climacteridae	White-browed Treecreeper	<i>Climacteris affinis</i>	3.1	0.0	1	3.1		10
Climacteridae	Brown Treecreeper	<i>Climacteris picumnus</i>	5.1	3.1	13	10.2	-0.32 (133)	1

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Ptilonorhynchidae	Spotted Catbird	<i>Ailuroedus melanotis</i>	18.7	16.2	16	45.3	0.02 (59)	10
Ptilonorhynchidae	Green Catbird	<i>Ailuroedus crassirostris</i>	9.7	4.1	16	16.4	-0.29 (130)	1
Ptilonorhynchidae	Tooth-billed Bowerbird	<i>Scenopoeetes dentirostris</i>	5.2	1.1	2	7.1		10
Ptilonorhynchidae	Satin Bowerbird	<i>Ptilonorhynchus violaceus</i>	9.5	5.1	22	17.9	-0.3 (131)	1
Maluridae	Superb Fairy-wren	<i>Malurus cyaneus</i>	6.5	3.4	93	12.1	-0.06 (80)	1
Maluridae	Variegated Fairy-wren	<i>Malurus lamberti</i>	4.5	3.4	38	10.1	-0.2 (115)	1
Maluridae	Southern Emu-wren	<i>Stipiturus malachurus</i>	7.0	3.3	13	12.4	0.0 (62)	1
Acanthizidae	Pilotbird	<i>Pycnoptilus floccosus</i>	16.9	10.0	3	33.4		10
Acanthizidae	Rockwarbler	<i>Origma solitaria</i>	17.1	4.0	2	23.8		10
Acanthizidae	Yellow-throated Scrubwren	<i>Sericornis citreogularis</i>	5.6	4.3	51	12.7	-0.21 (119)	1
Acanthizidae	White-browed Scrubwren	<i>Sericornis frontalis</i>	4.2	2.5	41	8.3	-0.31 (132)	1
Acanthizidae	Atherton Scrubwren	<i>Sericornis keri</i>	4.9	4.5	11	12.3	-0.21 (118)	10
Acanthizidae	Large-billed Scrubwren	<i>Sericornis magnirostra</i>	4.4	4.4	17	11.6	-0.23 (122)	1
Acanthizidae	Chestnut-rumped Heathwren	<i>Hylacola pyrrhopygia</i>	11.4	0.0	1	11.4		10
Acanthizidae	Striated Fieldwren	<i>Calamanthus fuliginosus</i>	8.6	0.0	1	8.6		10
Acanthizidae	Brown Gerygone	<i>Gerygone mouki</i>	4.2	1.9	32	7.3	-0.17 (111)	1
Acanthizidae	Western Gerygone	<i>Gerygone fusca</i>	5.4	0.0	1	5.4		10
Acanthizidae	White-throated Gerygone	<i>Gerygone albogularis</i>	5.1	3.8	3	11.4		10
Acanthizidae	Striated Thornbill	<i>Acanthiza lineata</i>	4.2	2.0	4	7.5		10
Acanthizidae	Yellow Thornbill	<i>Acanthiza nana</i>	6.3	2.4	17	10.2	-0.02 (71)	1
Acanthizidae	Yellow-rumped Thornbill	<i>Acanthiza chrysorrhoa</i>	6.6	3.7	4	12.7		10
Acanthizidae	Buff-rumped Thornbill	<i>Acanthiza reguloides</i>	4.3	1.8	14	7.3	-0.21 (117)	1
Acanthizidae	Brown Thornbill	<i>Acanthiza pusilla</i>	6.7	9.9	28	22.9	0.0 (63)	1
Pardalotidae	Spotted Pardalote	<i>Pardalotus punctatus</i>	4.0	1.9	7	7.1		10
Meliphagidae	Eastern Spinebill	<i>Acanthorhynchus tenuirostris</i>	5.8	2.6	39	10.1	-0.13 (102)	1
Meliphagidae	Lewin's Honeyeater	<i>Meliphaga lewinii</i>	8.2	6.0	32	18.1	-0.13 (101)	1
Meliphagidae	Yellow-faced Honeyeater	<i>Lichenostomus chrysops</i>	5.8	3.6	29	11.7	-0.19 (114)	1
Meliphagidae	Singing Honeyeater	<i>Lichenostomus virescens</i>	12.0	0.0	1	12.0		10
Meliphagidae	Yellow Honeyeater	<i>Lichenostomus flavus</i>	6.4	1.2	6	8.4		10
Meliphagidae	White-eared Honeyeater	<i>Lichenostomus leucotis</i>	8.8	3.7	7	14.8		10

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Meliphagidae	Fuscous Honeyeater	<i>Lichenostomus fuscus</i>	14.6	0.0	1	14.6		10
Meliphagidae	White-plumed Honeyeater	<i>Lichenostomus penicillatus</i>	9.8	5.6	23	19	0.02 (58)	1
Meliphagidae	Bell Miner	<i>Manorina melanophrys</i>	5.0	3.0	44	9.9	-0.33 (135)	1
Meliphagidae	Noisy Miner	<i>Manorina melanocephala</i>	7.5	14.9	37	32	-0.24 (123)	1
Meliphagidae	Spiny-cheeked Honeyeater	<i>Acanthagenys rufogularis</i>	9.2	1.3	3	11.4		10
Meliphagidae	Little Wattlebird	<i>Anthochaera chrysoptera</i>	7.3	3.0	40	12.2	-0.28 (129)	1
Meliphagidae	Red Wattlebird	<i>Anthochaera carunculata</i>	8.7	6.4	15	19.2	-0.25 (125)	1
Meliphagidae	White-fronted Chat	<i>Epthianura albifrons</i>	22.6	7.8	23	35.4	0.44 (7)	1
Meliphagidae	Dusky Honeyeater	<i>Myzomela obscura</i>	2.0	0.0	1	2.0		10
Meliphagidae	Tawny-crowned Honeyeater	<i>Glyciphila melanops</i>	9.8	6.7	11	20.8	0.03 (57)	1
Meliphagidae	Brown Honeyeater	<i>Lichmera indistincta</i>	9.8	5.6	16	19.0	0.09 (48)	1
Meliphagidae	New Holland Honeyeater	<i>Phylidonyris novaehollandiae</i>	7.9	6	47	17.8	-0.08 (85)	1
Meliphagidae	White-cheeked Honeyeater	<i>Phylidonyris niger</i>	2.3	0.0	2	2.3		10
Meliphagidae	Blue-faced Honeyeater	<i>Entomyzon cyanotis</i>	30.8	0.0	1	30.8		10
Meliphagidae	Helmeted Friarbird	<i>Philemon buceroides</i>	12.0	9.6	20	27.8	-0.1 (92)	10
Meliphagidae	Noisy Friarbird	<i>Philemon corniculatus</i>	11.1	5.3	55	19.8	-0.14 (104)	1
Meliphagidae	Little Friarbird	<i>Philemon citreogularis</i>	6.8	3.1	2	11.9		10
Meliphagidae	Striped Honeyeater	<i>Plectorhyncha lanceolata</i>	4.6	2.3	5	8.4		10
Pomatostomidae	White-browed Babbler	<i>Pomatostomus superciliosus</i>	16.9	4.4	2	24.1		10
Pomatostomidae	Chestnut-crowned Babbler	<i>Pomatostomus ruficeps</i>	11.8	4.0	2	18.3		10
Orthonychidae	Australian Logrunner	<i>Orthonyx temminckii</i>	4.5	1.5	5	7.0		10
Orthonychidae	Chowchilla	<i>Orthonyx spaldingii</i>	4.0	0.0	3	4.0		10
Eupetidae	Eastern Whipbird	<i>Psophodes olivaceus</i>	5.9	3.3	50	11.3	-0.34 (136)	1
Campephagidae	Black-faced Cuckoo-shrike	<i>Coracina novaehollandiae</i>	21.1	13.2	20	42.8	0.13 (33)	1
Campephagidae	White-bellied Cuckoo-shrike	<i>Coracina papuensis</i>	7.1	2.6	4	11.4		10
Campephagidae	Varied Triller	<i>Lalage leucomela</i>	38.7	0.0	1	38.7		10
Pachycephalidae	Crested Shrike-tit	<i>Falcunculus frontatus</i>	8.5	6.6	4	19.4		10
Pachycephalidae	Olive Whistler	<i>Pachycephala olivacea</i>	3.8	1.6	6	6.5		10
Pachycephalidae	Golden Whistler	<i>Pachycephala pectoralis</i>	7.9	3.9	18	14.3	-0.11 (95)	1
Pachycephalidae	Rufous Whistler	<i>Pachycephala rufiventris</i>	5.2	2.0	4	8.5		10

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Pachycephalidae	Grey Shrike-thrush	<i>Colluricincla harmonica</i>	12.8	11.4	15	31.6	-0.01 (68)	1
Oriolidae	Australasian Figbird	<i>Sphecotheres vieilloti</i>	7.8	3.7	12	13.9	-0.33 (134)	10
Oriolidae	Olive-backed Oriole	<i>Oriolus sagittatus</i>	11.3	5.9	33	21.0	-0.12 (99)	1
Artamidae	White-breasted Woodswallow	<i>Artamus leucorhynchus</i>	15.8	1.6	2	18.5		10
Artamidae	Masked Woodswallow	<i>Artamus personatus</i>	6.5	4.9	2	14.6		10
Artamidae	Black-faced Woodswallow	<i>Artamus cinereus</i>	11.8	5.6	3	21.1		10
Artamidae	Grey Butcherbird	<i>Cracticus torquatus</i>	19.3	13.3	10	41.2	0.12 (35)	1
Artamidae	Pied Butcherbird	<i>Cracticus nigrogularis</i>	9.5	4.9	8	17.5		10
Artamidae	Australian Magpie	<i>Cracticus tibicen</i>	10.9	8.7	91	25.2	-0.26 (127)	1
Artamidae	Australian Magpie~	<i>Cracticus tibicen</i>	40.3	28.2	21	86.6		7
Artamidae	Australian Magpie <sup>‡</sup>	<i>Cracticus tibicen</i>	11.1	5.9	27	20.8		7
Artamidae	Pied Currawong	<i>Strepera graculina</i>	15.1	11.6	26	34.2	-0.15 (107)	1
Dicruridae	Spangled Drongo	<i>Dicrurus bracteatus</i>	15.4	5.3	9	24.1		10
Rhipiduridae	Rufous Fantail	<i>Rhipidura rufifrons</i>	6.4	2	11	9.7	-0.08 (82)	1
Rhipiduridae	Grey Fantail	<i>Rhipidura albiscapa</i>	6.8	4.3	37	13.9	-0.02 (72)	1
Rhipiduridae	Willie Wagtail	<i>Rhipidura leucophrys</i>	11.8	9.7	46	27.8	0.10 (42)	1
Rhipiduridae	Willie Wagtail~	<i>Rhipidura leucophrys</i>	23.5	12.1	21	43.4		7
Rhipiduridae	Willie Wagtail <sup>‡</sup>	<i>Rhipidura leucophrys</i>	8.7	4.5	20	16.2		7
Corvidae	Australian Raven	<i>Corvus coronoides</i>	25.8	22.2	63	62.3	-0.01 (66)	1
Corvidae	Torresian Crow	<i>Corvus orru</i>	19.0	6.2	5	29.2		10
Monarchidae	Leaden Flycatcher	<i>Myiagra rubecula</i>	10.0	0.0	1	10.0		10
Monarchidae	Satin Flycatcher	<i>Myiagra cyanoleuca</i>	9.7	8.1	2	22.9		10
Monarchidae	Black-faced Monarch	<i>Monarcha melanopsis</i>	11.0	9.2	6	26.2		10
Monarchidae	Spectacled Monarch	<i>Symposiachrus trivirgatus</i>	5.7	2.9	3	10.4		10
Monarchidae	Magpie-lark	<i>Grallina cyanoleuca</i>	19.0	10.5	97	36.3	0.39 (11)	1
Monarchidae	Magpie-lark~	<i>Grallina cyanoleuca</i>	35.0	n/a	n/a	n/a		8
Monarchidae	Magpie-lark <sup>‡</sup>	<i>Grallina cyanoleuca</i>	12.0	n/a	n/a	n/a		8
Monarchidae	Magpie-lark~	<i>Grallina cyanoleuca</i>	35.4	13.9	22	58.3		7

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Monarchidae	Magpie-lark <sup>†</sup>	<i>Grallina cyanoleuca</i>	11.5	7.6	33	24.0		7
Corcoracidae	White-winged Chough	<i>Corcorax melanorhamphos</i>	16.2	7.3	14	28.2	-0.13 (103)	1
Corcoracidae	Apostlebird	<i>Struthidea cinerea</i>	20.7	23.8	4	59.9		10
Paradisaeidae	Victoria's Riflebird	<i>Ptiloris victoriae</i>	6.5	0.7	2	7.7		10
Petroicidae	Scarlet Robin	<i>Petroica boodang</i>	8.0	0.0	1	8.0		10
Petroicidae	Rose Robin	<i>Petroica rosea</i>	13.1	9.8	2	29.2		10
Petroicidae	Pale-yellow Robin	<i>Tregellasia capito</i>	8.5	1.7	3	11.3		10
Petroicidae	Eastern Yellow Robin	<i>Eopsaltria australis</i>	9.9	5.6	77	19.1	0.01 (60)	1
Petroicidae	Grey-headed Robin	<i>Heteromyias cinereifrons</i>	9.2	6.9	26	20.6	-0.10 (91)	9
Cisticolidae	Golden-headed Cisticola	<i>Cisticola exilis</i>	5.4	3.0	41	10.3	-0.11 (97)	1
Acrocephalidae	Australian Reed-warbler	<i>Acrocephalus australis</i>	11.5	9.4	20	26.9	0.11 (38)	1
Megaluridae	Tawny Grassbird	<i>Megalurus timoriensis</i>	6.0	3.6	7	12.0		10
Megaluridae	Little Grassbird	<i>Megalurus gramineus</i>	6.5	5.1	6	14.9		10
Timaliidae	Silvereye	<i>Zosterops lateralis</i>	6.1	3.8	34	12.4	-0.11 (98)	1
Hirundinae	Welcome Swallow	<i>Hirundo neoxena</i>	11.0	5.6	32	20.2	0.11 (36)	1
Hirundinidae	Fairy Martin	<i>Petrochelidon ariel</i>	8.9	4.5	2	16.4		10
Pycnonotidae	Red-whiskered Bulbul	<i>Pycnonotus jocosus</i>	18.4	13.2	25	40.1		1
Turdidae	Bassian Thrush	<i>Zoothera lunulata</i>	8.9	3.1	31	13.9	-0.26 (128)	1
Turdidae	Russet-tailed Thrush	<i>Zoothera heinei</i>	11.0	6.2	4	21.1		10
Turdidae	Common Blackbird <sup>~</sup>	<i>Turdus merula</i>	35.5	17.5	20	64.2	-0.10 (93)	7
Turdidae	Common Blackbird <sup>†</sup>	<i>Turdus merula</i>	11.6	8.4	30	25.3	-0.1 (93)	7
Sturnidae	Common Starling	<i>Sturnus vulgaris</i>	13.6	9.0	32	28.4	-0.02 (69)	1
Sturnidae	Common Myna	<i>Sturnus tristis</i>	11.6	9.4	40	27.1	-0.14 (106)	1
Nectariniidae	Olive-backed Sunbird	<i>Nectarinia jugularis</i>	10.9	5.7	7	20.2		10
Estrildidae	Zebra Finch	<i>Taeniopygia guttata</i>	14.7	11.3	10	33.2	0.26 (17)	10
Estrildidae	Double-barred Finch	<i>Taeniopygia bichenovii</i>	6.2	3.5	7	12.1		10
Estrildidae	Red-browed Finch	<i>Neochmia temporalis</i>	7.5	5.1	51	15.9	-0.02 (70)	1
Estrildidae	Nutmeg Mannikin	<i>Lonchura punctulata</i>	11.0	6.3	43	21.4	0.1 (40)	1
Estrildidae	Chestnut-breasted Mannikin	<i>Lonchura castaneothorax</i>	14.4	4.5	10	21.8	0.24 (22)	1

Family	Common name	Scientific name	Mean	St. Dev.	n	95 <sup>th</sup> percentile	Residual (rank)	Source
Passeridae	House Sparrow	<i>Passer domesticus</i>	13.2	8.6	18	27.3	0.11 (37)	1
Passeridae	Eurasian Tree-sparrow	<i>Passer montanus</i>	8.0	3.0	15	12.9	-0.08 (84)	1
Motacillidae	Australasian Pipit	<i>Anthus novaeseelandiae</i>	12.4	5.2	63	20.9	0.09 (47)	1
Motacillidae	White Wagtail**	<i>Motacilla alba</i>	7.7	1.8	16	10.7	-0.11 (96)	1
Fringillidae	Common Chaffinch	<i>Fringilla coelebs</i>	7.7	2.1	15	11.2	-0.09 (88)	1
Fringillidae	European Goldfinch	<i>Carduelis carduelis</i>	9.2	2.5	18	13.3	0.04 (53)	1
Fringillidae	Common Greenfinch	<i>Chloris chloris</i>	6.9	1.6	15	9.5	-0.17 (110)	1

799 <sup>1</sup> stimulus was dog, <sup>2</sup> boat, or <sup>3</sup> canoe; ^ data was not collected using the direct continuous method; ~ data collected in rural habitats; ‡ data  
800 collected in urban habitats, \*\* species vagrant in Australia.